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Survey of Insulation Used in Nuclear Power Plants and the Potential for Debris Generation

Prepared by R. Kolbe, E. Gahan

Burns and Roe, Inc.

Sandia National Laboratories

Prepared for
U.S. Nuclear Regulatory Commission

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ABSTRACT

In support of Unresolved Safety Issue, USI A-43, "Containment Emergency Sump Performance," 8 additional nuclear power plants (representative of different U.S. reactor manufacturers and architect-engineers) were surveyed to identify and document the types and amounts of insulation used, location within containment, components insulated, material characteristics, and methods of installation and attachment. These plants were selected to obtain survey information on "older" plants and supplements information previously reported in NUREG/CR-2403. In addition, a preliminary assessment was made of the potential for migration to the emergency sump of the insulation debris which might be generated as a result of the postulated loss-of-coolant accident (pipe break).

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LIST OF ABBREVIATIONS

ASME	American Society of Mechanical Engineers
BG&E	Baltimore Gas and Electric
B&R	Burns and Roe
CE	Combustion Engineering
CVCS	Chemical and Volume Control System
DST	Division of Safety Technology - USNRC
FSAR	Final Safety Analysis Report
LOCA	Loss-of-Coolant Accident
MWe	Megawatt Electrical
NRC	Nuclear Regulatory Commission
PWR	Pressurized Water Reactor
RBCCW	Reactor Building Closed Cooling Water
RC	Reactor Coolant
RCB	Reactor Containment Building
RCS	Reactor Coolant System
RG&E	Rochester Gas and Electric Corporation
RV	Reactor Vessel
SNL	Sandia National Laboratories
SS	Stainless Steel
USNRC	United States Nuclear Regulatory Commission
W	Westinghouse

SURVEY OF INSULATION USED IN NUCLEAR POWER PLANTS AND POTENTIAL FOR DEBRIS GENERATION

1. INTRODUCTION

The United States Nuclear Regulatory Commission (USNRC) Unresolved Safety Issue A-43, "Containment Emergency Sump Performance," deals with reactor containment building (RCB) emergency sump performance under post loss-of-coolant accident (LOCA) recirculation conditions[1]. This issue describes sump hydraulic performance (i.e., providing adequate net positive suction head to the recirculation pumps) and the effect of insulation debris generated in the course of the LOCA on the performance of the RCB emergency sump and the recirculation pumps.

The study was carried out under subcontract to Sandia Laboratories to identify and document the types and amounts of insulation, location within the RCB, components insulated, material characteristics, and methods of installation and attachment for eight selected plants; and therefore, extends the plant data base previously reported in NUREG/CR-2403[2] "Survey of Insulation Used in Nuclear Power Plants and the Potential for Debris Generation" dated October 1981.

The three basic concerns of this additional plant survey were:

- Types of insulation used and arrangement of piping within the RCB in the vicinity of pipe breaks in high energy (i.e., primary system) fluid piping postulated for LOCA conditions

- Descriptive details of the insulation used and the type that could be dislodged, thereby becoming a source of debris as the result of a major pipe break

- Location and configuration of the sumps that serve as intakes for the emergency long-term recirculation core cooling, and the communicating paths by which insulation debris generated by a major pipe break could migrate to the sump

Plant design information was obtained for 8 plants representative of 2 U.S. reactor manufacturers. The selected sample consisted of plants designed by 5 architect-engineering firms for 8 utilities with plant startup dates ranging from 1968 to 1977; thereby providing information on the older plants. This work is a continuation of a survey originally performed for 11 plants, both operating and under construction, and reported previously in NUREG/CR-2403.

The information for each plant was assembled in a data package that included a preliminary insulation debris hazard analysis. These plant information packages are included as appendixes in this report.

2. REACTOR PLANTS INVESTIGATED

Table 2-1 lists the plants selected by the Division of Safety Technology (DST) of NRC for conducting this generic insulation survey. Analysis of the design information was performed for all of these plants.

A letter was sent by NRC to these utilities listing the type of plant design and insulation documentation needed. Additional information or clarification was by Burns and Roe (B&R) staff obtained by telephone. The information requested was:

- Type and description of thermal insulation used for piping and equipment inside the RCB, including dimensional details
- Specification and contractor details for procurement and installation of insulation in the RCB
- Drawings of installation details of insulation including methods of attaching, spacing, and joining insulation
- Design drawings such as general arrangement drawings of the RCB; structural drawings of the RCB; drawings of piping inside the RCB including supports, restraints and anchors; flow diagrams of the systems that have piping inside the RCB; drawings that depict the RCB sumps, drainage to the sump, and protection for pump suction intakes; and drainage details in the RCB.

3. TYPES OF INSULATION EMPLOYED

Various types of thermal and antisweat insulation are used inside the RCB. Thermal insulation is used for reactor coolant, main steam, feedwater, and emergency core-cooling piping. Antisweat insulation is used for cooling-water, chilled-water, refrigerant, and cold-gas piping.

Types of thermal insulation found in use were:

- Reflective metallic insulation
- Totally encapsulated insulation with the following insulation filler types
    - Calcium silicate
    - Expanded perlite
    - Fiberglass
    - Mineral wool fiber

TABLE 2-1. Reactor plants selected for follow-up insulation survey

Plant and Location	Reactor	Rating	Startup Date	Utility	Architect-Engineer
Millstone Unit 2 Waterford, Conn.	CE-PWR	870 MWe	1975	Northeast Utilities	Bechtel
St. Lucie Unit 1 Hutchinson Island, Fla.	CE-PWR	777 MWe	1976	Florida Power & Light Co.	Ebasco
Calvert Cliffs Units 1&2 Lusby, Md.	CE-PWR	850 MWe	1975*	Baltimore Gas & Electric Co.	Bechtel
Robert E. Ginna Ontario, N.Y.	W-PWR	490 MWe	1970	Rochester Gas & Electric Corp.	Gilbert
Prairie Island Units 1&2 Red Wing, Minn.	W-PWR	520 MWe	1973**	Northern States Power Co.	Fluor Power Services
Kewaunee Carlton, Wis.	W-PWR	535 MWe	1974	Wisconsin Public Services Corporation	Fluor Power Services
Haddam Neck Haddam Neck, Conn.	W-PWR	575 MWe	1968	Connecticut Yankee Atomic Power Co.	Stone & Webster
H.B. Robinson Hartsville, S.C.	W-PWR	665 MWe	1971	Carolina Power & Light Co.	Ebasco

* Unit 2 startup date is 1977
**Unit 2 startup date is 1974
Source: Nuclear News, August 1981

- Cerablanket
- Unibestos

- Mineral fiber blanket metal mesh covered
- Mineral fiber/wool blanket jacketed with asbestos cloth
- Calcium silicate molded block jacketed insulation
- Unibestos or thermobestos molded block jacketed insulation

Types of antisweat insulation found in use were:

- Fiberglass jacketed insulation
- Urethane and polyurethane foam insulation

The early use of reflective metallic insulation in the reactor coolant system was limited to the reactor vessel because of the insulation's anticipated long life and the system's inaccessibility once it was installed inside the reactor shield wall. To fulfill the code requirement for inservice inspection of the reactor coolant and emergency core-cooling systems, removable reflective metallic insulation was tried and found satisfactory. Now some newer plants use this type of insulation exclusively in these systems. In addition, totally encapsulated removable insulation is being used in these systems. Mineral fiber blankets, calcium silicate molded blocks, and asbestos were the traditional choices in fossil power plants for high-temperature thermal insulation. Mineral fiber blankets were preferred for valves and equipment where access was needed for maintenance. Asbestos was used for thermal insulation because it is much sturdier than the calcium silicate block that has replaced it in modern stations because of the health hazard properties of asbestos.

Table 3-1 summarizes the types and percentages of each insulation utilized within the primary coolant system shield wall in the 8 plants surveyed. It shows that the older plants use a large amount of calcium silicate and unibestos block insulation compared to the newer plants which utilize mostly reflective metallic or totally encapsulated insulation. Appendix A describes each type of insulation.

Although some insulation used within the RCB is outside the primary coolant system shield wall, the survey considered only insulation inside the shield wall, because:

- The major portion of the insulation is within the shield wall.
- The location of a piping break that most likely would result in significant debris generation would be within the shield wall.

It should be recognized that the antisweat insulation (i.e. Fiberglass jacketed, urethane and polyurethane foam) is not shown in Table 3-1

Table 3-1. Types and percentages of insulation used within the primary coolant system wall in plants surveyed

Plant	Types of Insulation and Percentage*					
	Reflective Metallic (Figs.A-1,2,3 & 4) ***	Totally Encap-sulated (Fig. A-5) ***	Mineral Fiber/Wool Blanket	Calcium Silicate Block (Fig. A-6) ***	Unibestos & Thermobestos Block (Fig. A-6) ***	Fiberglass
Millstone Unit 2	25	35	5	30	-	-
St. Lucie Unit 1	10	-	-	90	-	-
Calvert Cliffs Units 1&2	41	59	-	-	-	-
Robert E. Ginna	-	-	5	80	10	0
Prairie Island Units 1 & 2	98	-	-	-	-	2
Kewaunee	61	-	-	-	39	-
Haddam Neck	3	-	-	-	95**	1
H. B. Robinson	-	-	-	15	85	-

* Tolerance is +20 percent
** Unibestos is currently being replaced by Calcium Silicate. However both types of insulation have the same sump blockage characteristics.
***See Appendix A for referenced figures.

because the quantities of this type of insulation contained inside the shield wall were not judged to be significant (less than 2%).

4. SUMMARY

Table 4-1 shows the types of insulation inside the RCB, the location of the emergency sump, a summary of the migration potential of debris to reach the emergency sump as a result of a pipe break for each plant studied and a preliminary assessment of potential for sump screen blockage. Data from 8 plants have been analyzed: 3 Combustion Engineering (CE) units, and 5 Westinghouse (W) units.

In Millstone Unit 2, it may be possible for some reflective metallic or totally encapsulated mineral wool to fall under the shield wall and onto the sump. Also, it is possible for calcium silicate and foam insulation to migrate to the sump. In St. Lucie Units 3 & 4, it may be possible for calcium silicate to migrate towards the sump during the initial flooding of the containment. In Calvert Cliffs Units 1 & 2, it is possible for some local reflective metallic and encapsulated mineral wool to fall onto the sump. In Robert E. Ginna, it is possible for the asbestos, calcium silicate and fiberglass to migrate to the sump. In Prairie Island, some reflective metallic directly over the sump could fall onto it, and blanket insulation could migrate to the sump. In Kewaunee, some reflective metallic insulation could be transported towards the sump. Asbestos insulation because of its density, will float and migrate towards the sump. In Haddam Neck, the asbestos, calcium silicate, polyurethane and fiberglass could migrate towards the sump since it all floats. In H.B. Robinson, the possibility for insulation to reach the sump screen appears very limited because of the location of the sump and baffles surrounding it.

In general, all reflective metallic type of insulation sections or panels falling into containment will sink rapidly and most likely not be transported toward the emergency sump. Other types, including totally encapsulated with non-metallic inner materials, mineral wool, calcium silicate, unibestos, thermobestos, and fiberglass, can be expected to float initially, to migrate towards the emergency sump and to sink eventually. The rate and extent of water absorption, and thus the time to sink, will depend on such characteristics as the basic hygroscopicity of the material, cellular construction and design of the encapsulation. Discussion with insulation manufacturers (Owens-Corning, Pittsburg Plate Glass and Johns-Mansville) have indicated that meaningful information on water absorption and time to sink is not available; therefore, where non-metallic type insulations have been found in this survey, a potential for sump intake blockage has been indicated. The actual blockage, if any, for a given plant would depend upon determination of the exact insulation types used and their flotation characteristics, followed by an analysis using the methodology developed during this study.[3] Separate investigations of flotation characteristics on a generic basis for use in specific plant analyses may be desirable. It is understood that selective testing to determine such characteristics is being planned by the Alden Research Laboratories.

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TABLE 4-1. Summary Table

Plant and Reactor Manufacturer	Types of Insulation	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
Millstone Unit 2 (CE)	Reflective metallic used on reactor vessel and cavity. Encapsulated mineral wool used on reactor coolant system, steam generator and pressurizer. Stainless steel lagged mineral wool used on main steam and feedwater pipe. Urethane foam was used on component cooling and calcium silicate on remainder of systems.	Partially outside and under the reactor shield wall. (See Figure B-3)	Foam insulation could float towards the sump. The potential for a large amount of insulation to migrate to the sump is small.
St. Lucie Unit 1 (CE)	Metal jacketed or encapsulated calcium silicate block used almost exclusively. Reactor coolant pump uses reflective metallic.	Outside the shield wall in a trench surrounding the shield wall (see Figure C-2)	The calcium silicate could float out of the shield wall and towards the sump during the initial flooding of the containment. The potential to block the sump screens exists. The reflective metallic appears to pose no problem.
Calvert Cliffs Unit 1 & 2 (CE)	Reflective metallic has been used on the reactor coolant piping system, reactor vessel, steam generators, pressurizers and reactor cavity. Encapsulated mineral wool has been used on the reactor coolant pumps, steam generators, pressurizer, regenerative heat exchanger, and reactor dome.	Inside the reactor shield wall next to the reactor vessel wall (see Figure D-2)	Insulation from small diameter pipe over the sump could fall onto it. The potential for a large amount of insulation to migrate to the sump is small.

TABLE 4-1. (Continued)

Plant and Reactor Manufacturer	Types of Insulation	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
Robert E. Ginna Unit 1 (W)	Calcium silicate used almost exclusively. Ceramic glass fiber blankets are used on removal sections. Fiberglass is used on service water cooling system.	Below part of the shield wall and the reactor refueling channel (see Figure E-2).	Calcium silicate could float towards the sump and then sink. There exist numerous insulated pipe and equipment items in the vicinity of the sump. The potential to block the screens exists.
Prairie Island Units 1 & 2 (W)	Reflective metallic is used throughout the plant. Pipe hanger and restraints are covered with fiberous glass blankets.	Located outside the shield wall (see Figure F-2).	Fibrous glass blankets could float and migrate to the sump. There are some small pipes over the sump. Insulation from these pipes could fall onto the sump. Potential for a large amount of insulation to migrate to the sump is small.
Kewaunee Unit 1 (W)	Reflective metallic is used almost exclusivly. Thermobestos is used to cover the bulk of steam generators, main steam and feedwater piping.	Outside shield wall (see Figure G-2)	Thermobestos could float and migrate to the sump and sink. Insulation could be dislodged from pipe in the vicinity of the sump and fall onto it. The potential to block the screens exists.
Haddam Neck Unit 1 (W)	Thermobestos insulation was used on the reactor and hot pipes. Fiberglass insulation was used at valves and welds. Foam insulation was used for cold water pipes. The reactor vessel is also covered in small part by reflective metallic.	Inside crane wall next to fuel transfer channel (see Figure H-2).	The thermobestos and fiberglass insulation could float and migrate to the sump and sink. The potential to block the screens exists.

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TABLE 4-1. (Continued)

Plant and Reactor Manufacturer	Types of Insulation	Location of Emergency Sump	Preliminary Assessment of Migration Potential of Debris Generated as a Result of a Pipe Break
H. B. Robinson (W)	Unibestos was originally used for all equipment and systems. Approximately, 15 percent of the unibestos has been replaced by calcium silicate.	Along the outer edge of shield or crane wall (see Figure I-2).	There exists little possibility for insulation to reach the sump from inside the shield wall because of screens covering drainage openings. Outside the shield wall, a set of baffles protect the sump screens.

5. REFERENCES

1. U.S. Nuclear Regulatory Commission, "Containment Emergency Sump Performance," USNRC Unresolved Safety Issue A-43, January 16, 1981. Available in the NRC Public Document Room for inspection and copying for a fee.

2. U.S. Nuclear Regulatory Commission, "Survey of Insulation Used in Nuclear Power Plants and the Potential for Debris Generation," NUREG/CR-2403, October 1981.

3. Burns and Roe, Inc., "Methodology for Evaluation of Insulation Debris Generation," prepared under Sandia Laboratories contract 61-4219, December 1981.

APPENDIX A

DESCRIPTION OF INSULATION FOUND IN PLANTS SURVEYED

A description of each type of insulation found from the survey in each of the 8 plants follows.

A. RELECTIVE METALLIC INSULATION

Metallic all-metal removable insulation is provided primarily by Diamond Power Specialty Company and Transco to the utility industry for the primary coolant system, the reactor vessel, piping and equipment, and American Society of Mechanical Engineers (ASME) Section III Class 2 components and equipment. This type of insulation controls heat loss and enables the owner/operator to comply with the inservice inspection requirements of ASME Code Section XI1 because it is easily removed. Reflective insulation is constructed in various combinations of materials ranging from all stainless steel to a combination of aluminum and stainless steel. (See Figure A-1.)

The insulation used for piping is typically 2 feet or longer in length, 3 to 4 in. thick, and split into two sections with each section covering half of the pipe. These sections are composed of 24-to 28-gauge stainless steel outer sheets which fully enclose 2 to 6 mil stainless or aluminum sheets. The inner sheets are built up of two to three sheets per inch of insulation thickness. (See Figure A-2.)

The insulation panels used for large equipment such as the reactor vessel, pressurizer, and steam generators are typically 2 by 6 ft and have a construction similar to the insulation described for piping. (See Figures A-3 and A-4.)

All panels on piping and equipment welds that require inservice inspection are fastened by quick release buckle bands for ease of removal. Nonremovable insulation panels are fastened, one to another, with self-tapping screws.

Diamond Power Specialty Company[2] has conducted tests of the response of their reflective insulation to loss-of-coolant accident (LOCA) conditions. Based on these tests, Diamond Power concluded that in a LOCA:

- All-Metal reflective insulation will be crushed instantly near pipe breaks because of the external differential pressure
- All-Metal reflective insulation sections or panels in line with the jet from a pipe break will be blown off the pipe or vessel because of the internal differential pressure that would develop
- All-Metal reflective insulation sections or panels in the immediate vicinity of a pipe break will be transported by the steam or air flow

- All-Metal reflective insulation sections or panels falling into containment will sink rather than be transported because of low velocity to the emergency pump.

B. TOTALLY ENCAPSULATED INSULATION

Diamond Power, Transco, and Johns-Manville produce encapsulated insulation that is used on pressurizers in combination with reflective insulation. The construction of the totally encapsulated modules is exactly the same as that of reflective ones, except that a nonreflective material is used between the inner and outer casings instead of stainless steel. The type of insulation used between the casings for the different plants surveyed was as follows.

Calcium Silicate Molded Block

Calcium silicate molded block insulation is a molded, high-temperature pipe and block insulation composed of hydrous calcium silicate. It is light weight, has low thermal conductivity, and high structural strength, and is insoluble in water. Its density (dry) is 13 to 14 lb. per cubic foot. Its transverse strength (based on 1-1/2 in. thickness) is 35 to 60 psi. Its compressive strength (based on 1-1/2 in. thickness) is 60 to 250 psi. The molded blocks are provided in thicknesses of up to 4 in. and lengths of up to 3 ft. (See Figure A-5.)

Expanded Perlite Molded Block

Expanded perlite molded block insulation is composed of expanded perlite with reinforced mineral fiber and inorganic binders. It is an insulating material with properties similar to those of calcium silicate insulation. The average maximum density is 14 lb. per cubic foot. Its flexural strength should be not less than 35 psi, and its compressive strength dry is 60 psi and wet is 25 psi.

Fiberglass Molded Block

Fiberglass molded block insulation is composed of glass that has been foamed or cellulated under molten conditions, annealed, and set to form a rigid incombustible material with hermetically sealed cells. The density is between 7.0 and 9.5 lb. per cubic foot. Its flexural strength is 60 psi, and compressive strength is 75 psi. The water vapor permeability is 0.005 perm-in. Water absorption is 0.5 percent by volume. (See Figure A-5.)

Mineral Wool Fiber Block

Mineral wool fiber block insulation is made of a mineral substance, such as rock, slag, or glass processed from a molten state into fibrous form. The density, depending on kind, ranges from 10 to 20 lb. per cubic foot. The strength varies considerably with the classes of insulation. The moisture is less than 1.0 percent by volume.

Cerablanket

Cerablanket (trade name), manufactured by Johns-Manville, is a ceramic fibrous insulating material with a density of 6 lb. per cubic foot. The Cerablanket is enclosed in 0.006 in. metal foil and then encapsulated in a reflective insulation structure.

Unibestos

Unibestos insulation is composed of lime and diatomaceous silica taken from natural deposits. These basic ingredients are bonded with asbestos fiber possessing the tensile strength of piano wire. This composition is then encased in stainless steel sheet.

C. MINERAL FIBER BLANKET METAL MESH COVERED

Mineral fiber blanket metal mesh covered insulation consists of blanket thermal insulation covered by flexible metal-mesh facings on one or both sides, and held together by heat-resistant ties extending from one face to the other. Rolls or flat sheets of blanket are usually 4 by 8 ft. with densities between 3 and 12 lb. per cubic foot, and thicknesses of up to 2 in.

D. MINERAL FIBER/WOOL BLANKET JACKETED WITH ASBESTOS CLOTH

Mineral fiber/wool blanket jacketed with asbestos cloth consists of a blanket insulating material of mineral wool or refractory mineral fiber covered with an inner cover of asbestos cloth and an outer cover of fine mesh glass cloth. The density of the blanket material is between 3 and 12 lb. per cubic foot. Blankets are secured with hooks and hog rings.

E. CALCIUM SILICATE MOLDED BLOCK JACKETED INSULATION

Calcium silicate molded block jacketed insulation has been utilized in a number of plants. The jacketing used is fiberglass cloth, stainless steel, or aluminum. Joints are sealed against the entrance of water by sealing compounds. The properties of calcium silicate have been described previously. (See Figure A-6.)

F. UNIBESTOS OR THERMOBESTOS MOLDED BLOCK JACKETED INSULATION

Unibestos or thermobestos molded block jacketed insulation is composed of lime and diatomaceous silica taken from natural deposits estimated to be millions of years old. These basic ingredients are bonded with asbestos fibers possessing the tensile strength of piano wire. Basically, this type of insulation is calcium silicate held together by asbestos fibers. Since asbestos is now banned for use by the Occupational Safety and Health Act, insulation using this material is no longer manufactured. This insulation is remarkably strong and rigid and, therefore, does not require metal jacketing. It is extremely light, with a density of 11 lb. per cubic foot, and not damaged

by water. At some plants, unibestos is used but jacketed with fiberglass cloth or stainless steel sheets. (See Figure A-6.)

G. FIBERGLASS JACKETED INSULATION (ANTISWEAT)

Fiberglass insulation with metal jacketing is a rigid fiberglass pipe insulation made from long, flame-attenuated glass fibers with a thermosetting resin. The polished metal jacket is made of 0.016 in. aluminum or 0.010-in. stainless steel and usually has a longitudinal seam closure that locks the insulation and jacket in place. The insulation with jackets is produced in 3-ft. lengths. The density of the fiberglass ranges from 7.0 to 9.5 lb. per cubic foot.

H. URETHANE AND POLYURETHANE FOAM INSULATION (ANTISWEAT)

Urethane and polyurethane foam antisweat insulation is a rigid cellular foam plastic that combines light weight and strength with exceptional thermal insulating efficency. The foam is a vast cross-linked network of closed cells, each cell a tiny bubble full of gas that accounts for 90 percent of its volume. Its density ranges from 1.8 to 4.0 per cubic foot. The insulation is sealed with a vapor barrier of aluminum foil or a metal jacket.

I. REFERENCES

1. ASME Boiler & Pressure Vessel Code, Section XI, 1980, "Rules for Inservice Inspection of Nuclear Power Plant Components," ASME, New York, N.Y.

2. Diamond Power Specialty Company, "Response of Mirror Insulation to LOCA Conditions," Diamond Power Specialty Company Report, May 30, 1978.

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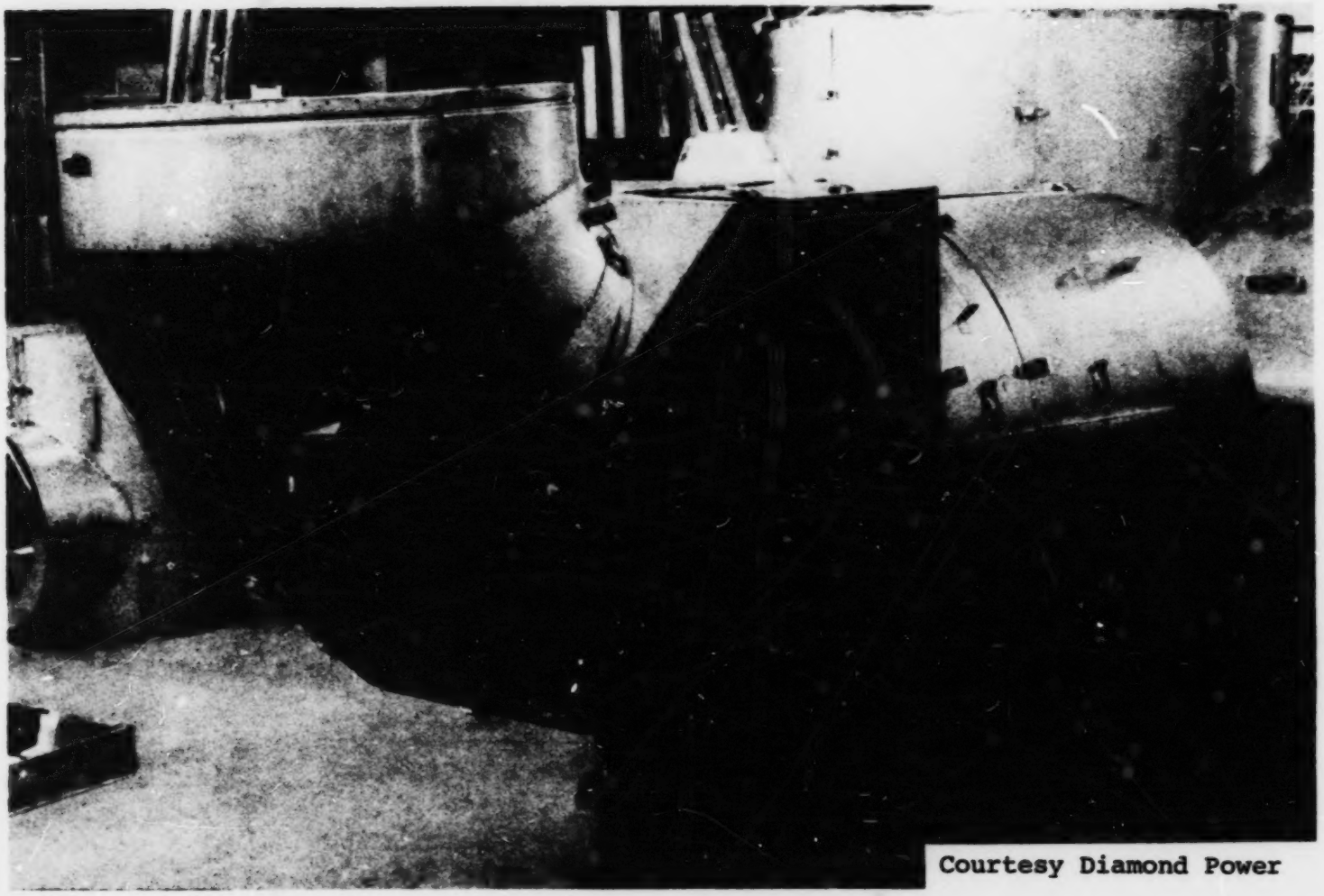

Courtesy Diamond Power

Figure A-1. Specially designed Mirror valve and elbow insulation for 24" residual heat removal at Vermont Yankee Nuclear Station.

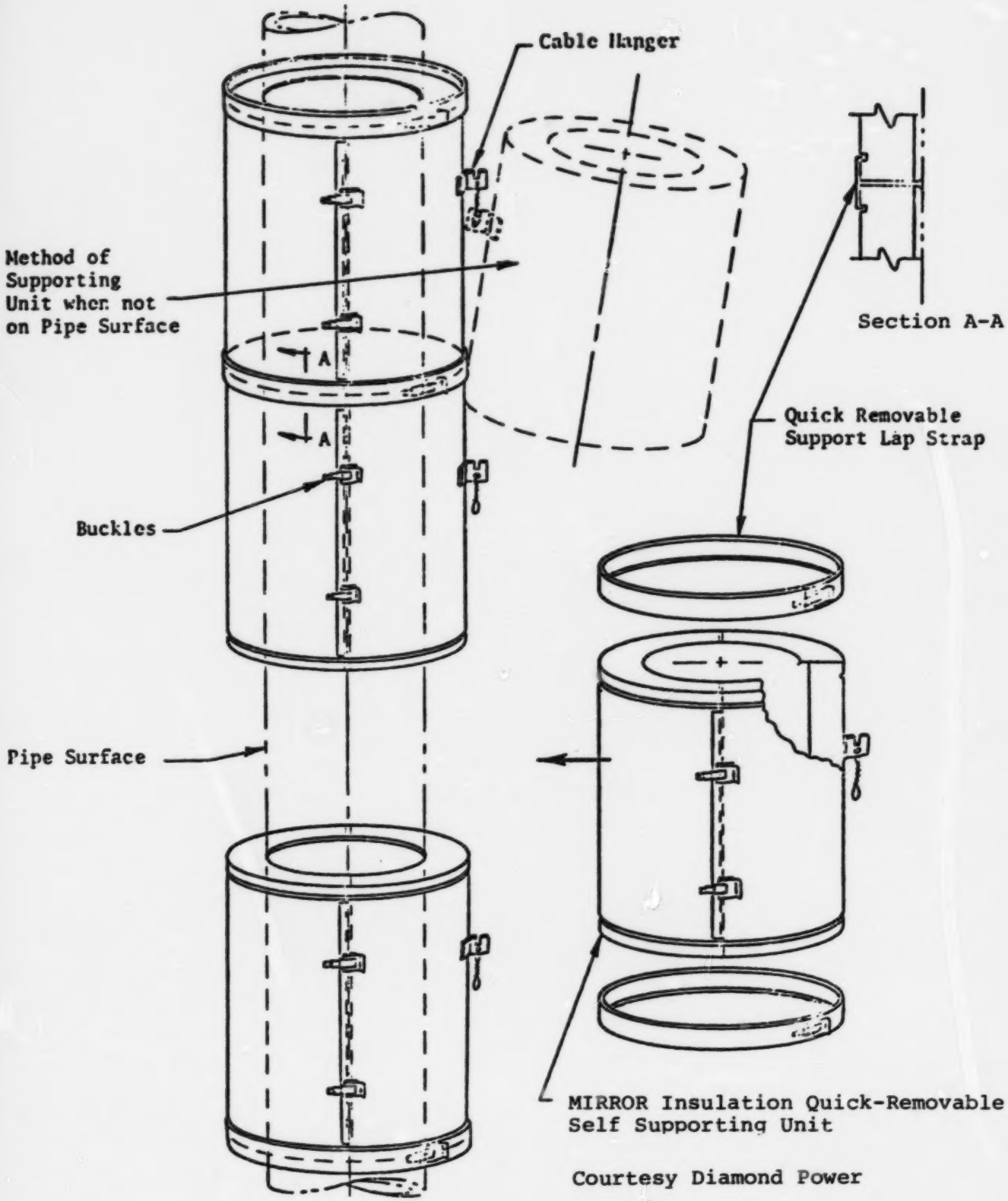

Figure A-2. MIRROR Insulation

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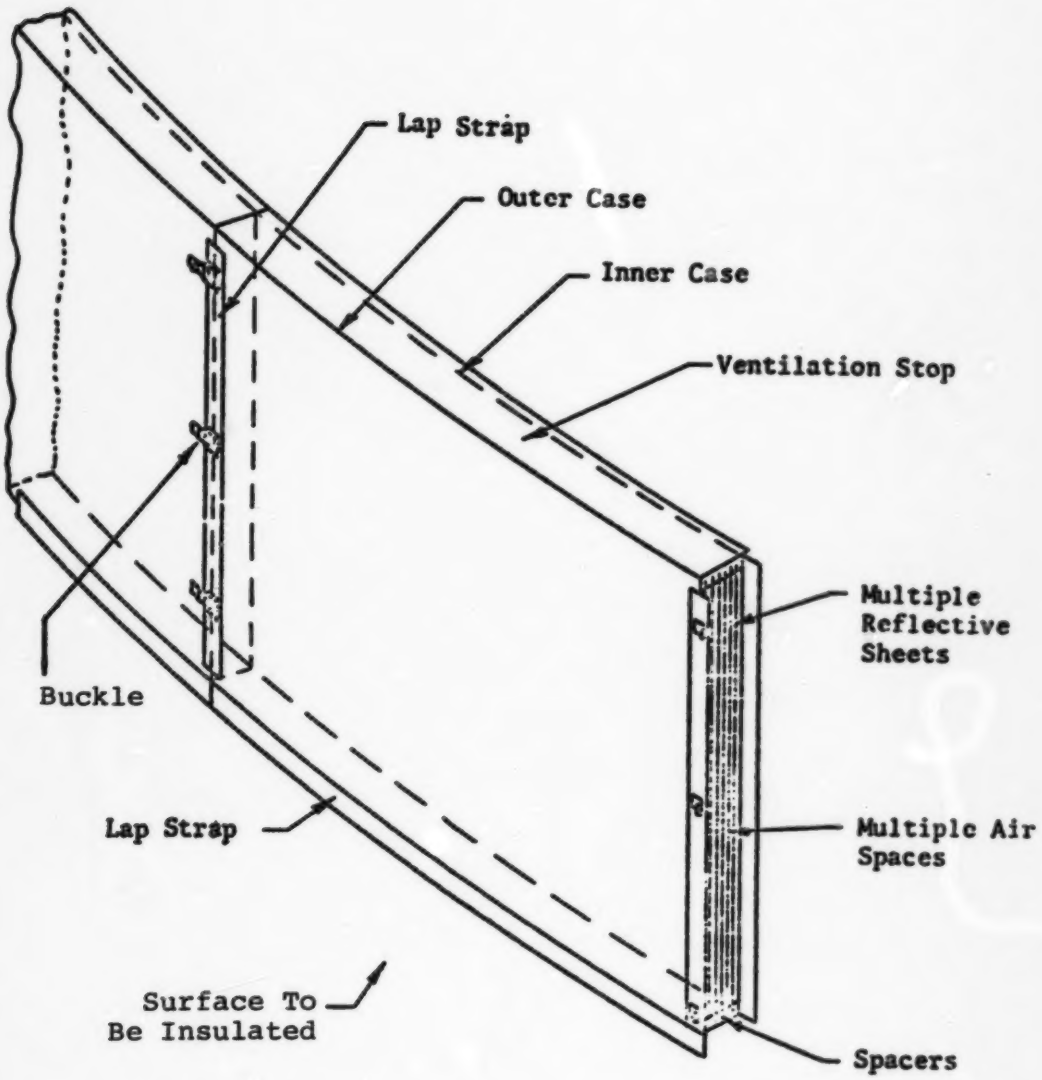

Courtesy Diamond Power

Figure A-3. Typical buckled panel arrangement

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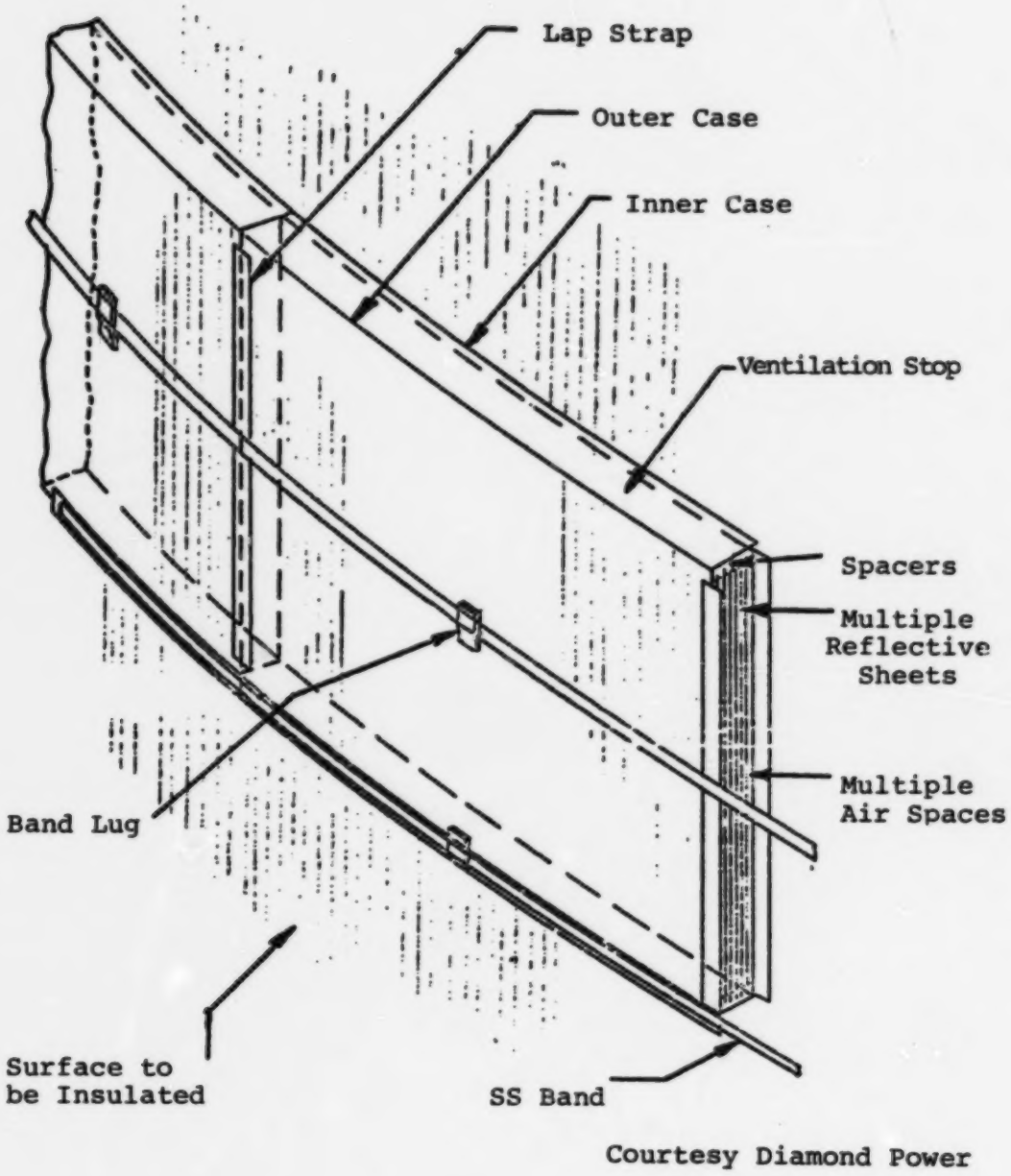

Figure A-4. Typical banded panel arrangement

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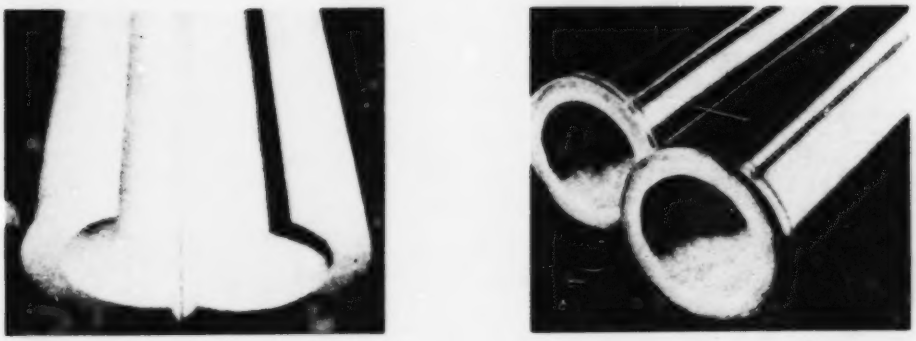
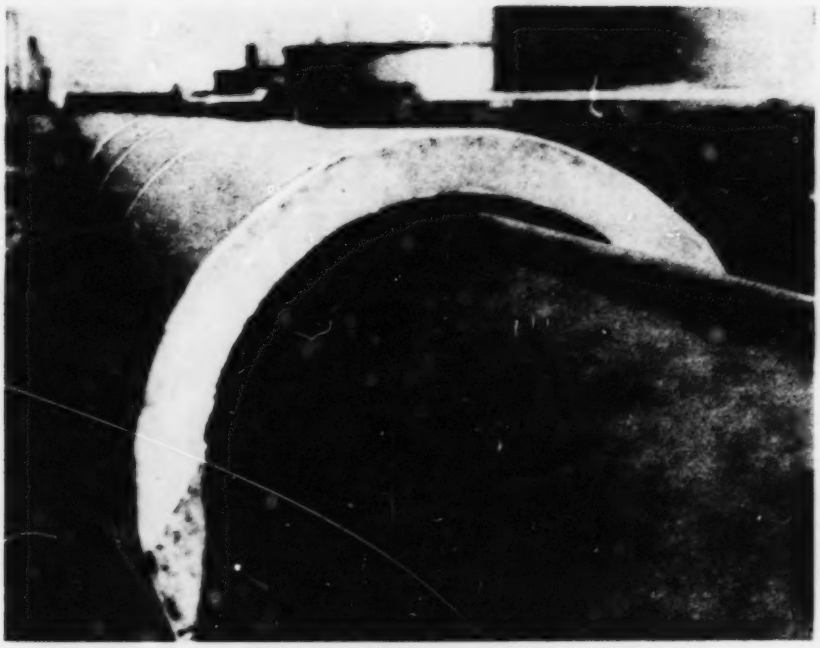


(a) (b)



(c)

Figure A-5. (a) Calcium silicate molded black insulation;
(b) Figerglass molded block insulation;
(c) Installed calcium silicate insulation.

Courtesy Owens Corning Fiberglas Corp.

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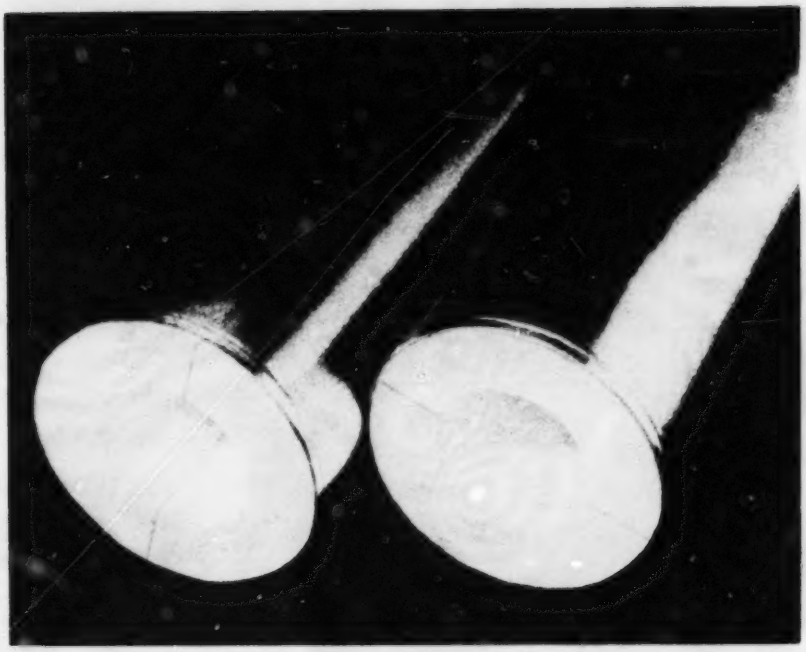

Courtesy Owens Corning Fiberglas Corp.

Figure A-6. Calcium silicate or unibestos molded block jacketed insulation

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APPENDIX B
MILLSTONE UNIT 2

PRELIMINARY ASSESSMENT OF
INSULATION DEBRIS GENERATED DURING A
PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 870 MWe, Combusion Engineering, PWR, Millstone Unit 2 which started commercial operation in 1975.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the emergency intake sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump

3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break.

Five types of insulation are utilized within the containment. These are:

Reflective metallic has been used on the reactor vessel and cavity. Encapsulated mineral wool has been used on the reactor coolant system, steam generator and pressurizer. Mineral wool lagged with stainless steel has been used on the main steam and feedwater lines. Urethane foam was used on cooling system pipe and calcium silicate on the balance of pipe.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building piping, flow diagrams, emergency sump details and insulation details for Millstone.

1. Documentation

   a. Letter from Northeast Utilities to NRC dated December 29, 1980 on Containment Sump - Information Request.

2. Drawings

   a. General Arrangement - Containment and Reactor Building

25203-27014	Reactor Plant El. 14'-6" & 38'-6"
25203-27018	Reactor Plant El. (-)5'-0" & (-)3'-6"
25203-27019	Reactor Plant El. (-)25'-6" & (-)22'-6"

25203-27020	Reactor Plant El. (-)45'-6"
25203-27021	Reactor Plant Section "A-A"

b. Piping and Instrument Diagrams

25203-26002	Main Steam and Reheat
25203-26005	Condensate and Feedwater System
25203-26014	Reactor Coolant System
25203-26015	Safety Injection System and Containment Spray System
25203-26017	Chemical and Volume Control System
25203-26022 Sh. 1 of 2	R.B.C.C.W. System
25203-26022 Sh. 2 of 2	R.B.C.C.W. System

c. Piping Layout Drawings

25203-20035	Piping Plan - El. (-)22'-6"
25203-20036	Piping Plan - El. (-)3'-6"
25203-20037	Piping Plan - El. 14'-6"
25203-20038	Piping Plan - El. 38'-6"
25203-20039	Piping Sections "A-A" and "B-B"
25203-20040	Containment Penetration Piping Details

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the equipment and systems inside primary containment containing insulation. The list includes the equipment, the system, nominal pipe sizes inside containment and the type of insulation used for each system.

System	Diameter Inches	Type of Insulation
Safety Injection	12	Calcium Silicate
Pressurizer Surge Line	12	Calcium Silicate
Reactor Coolant	42,30	Encapsulated Mineral Wool
Pressurizer Spray Line	3	Calcium Silicate
Shutdown Cooling	12	Calcium Silicate
Feedwater	18	Mineral Wool Lagged with SS
Main Steam	34	Mineral Wool Lagged with SS
Component Cooling	6,4,3	Urethane Foam
Equipment Inside Primary Containment		
Reactor Vessel		Reflective Metallic
Steam Generator		Encapsulated Mineral Wool
Pressurizer		Encapsulated Mineral Wool
Reactor Coolant Pumps		Encapsulated Mineral Wool

D. TYPICAL INSULATION DETAILS

Two mineral wool types of insulation are used within the containment building. One type is the totally enclosed stainless steel panels. The other type is mineral wool lagged with stainless steel which was used only on the main steam and feedwater lines. No metal lagged mineral wool was used on pipes below the 38'-6" elevation.

The hydrous calcium silicate used is molded sections covered with sheet stainless steel. The reflective metallic insulation was described in Appendix A.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[1] for a list of the pipe break locations for high energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

Northeast Utilities submitted answers to several questions regarding the insulation debris problem. The question numbers relating to this problem are 6.1, 6.29 and 6.33. The answers to these questions can be found in the FSAR. Question 6.1 requested information about the sump design details, while, Question 6.29 requested information about the configuration of the suction lines for recirculation. The answer to Question 6.33 provides an evaluation of the maximum amount of insulation which could be dislodged during a loss-of-coolant accident.

G. PRELIMINARY INSULATION DEBRIS HAZARDS ANALYSIS

Figures B-1 and B-2 are simplified sketches of the Millstone Unit 2 reactor containment. The reactor vessel, steam generators, pressurizers and associated piping are all located inside the shield wall. The emergency sump is located partially under the shield wall and extends outside the shield wall. The location of the emergency sump on the basement floor at El. (-)22'-6" is shown in Figure B-2. Figure B-3 shows the detail of the emergency sump. The sump is divided into two parts and a separate intake pipe from each part goes to the emergency core cooling system. The sump is surrounded by a 3'-9" high 7' x 12' screen to catch debris. The screen and and the wall dividing the sump is constructed of 1-1/4" grating protecting #3-3/4 wire mesh cloth calendered .080" wire, .187 opening. The wire mesh cloth is fastened to the inside of the grating with 1/4" bolts and washers.

For pipe breaks inside the shield wall, the potential for a large amount of insulation to migrate towards the sump is very small. A grate floor exists at El. 2'-6" and a concrete floor exists at El. (-)0'-7 1/3". These floors would catch most of the insulation. Similarly, outside the shield wall the potential problem is very small. Three floors exist at El. 36'-6", 14'-6" and (-)3'-6", which would catch most of the insulation. However, a small amount of insulation could migrate down the stairwells and other openings.

For pipe breaks inside the shield wall below El. (-)0'-7 1/3" or outside the shield wall below El. (-)3'-6", the insulation debris could migrate to the sump. The least likely insulation to reach the sump is the mineral wool lagged with stainless steel since it is not used below 38'-6" elevation. The foam insulation would float. The reflective metallic and totally encapsulated mineral wool would sink.

H. REFERENCE

1. Millstone Unit 2, Final Safety Analysis Report, Northeast Utilities, Berlin, CT.

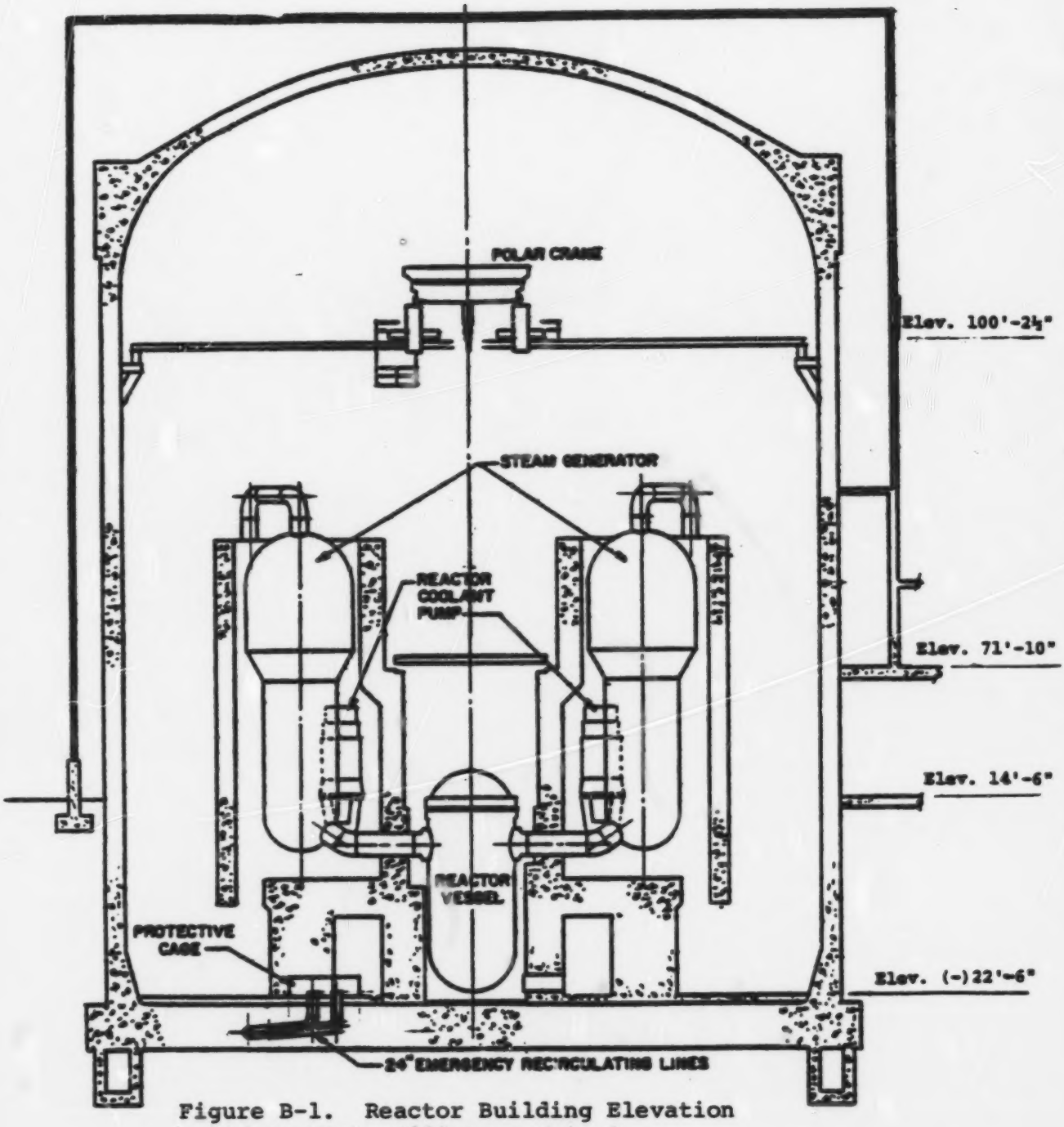

Figure B-1. Reactor Building Elevation Arrangement, Millstone Unit 2

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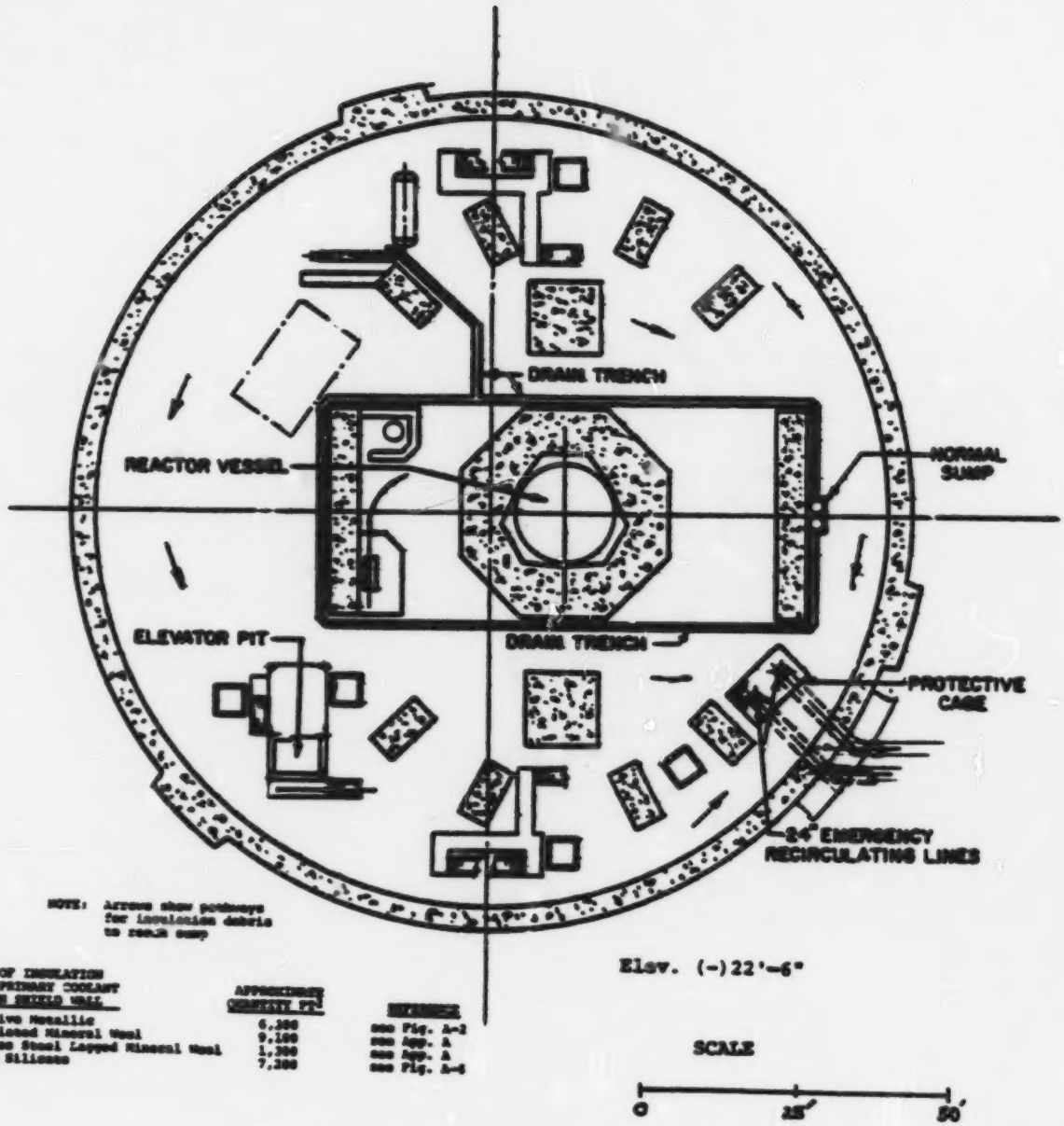

Figure B-2. Reactor Building Plan, Millstone Unit 2

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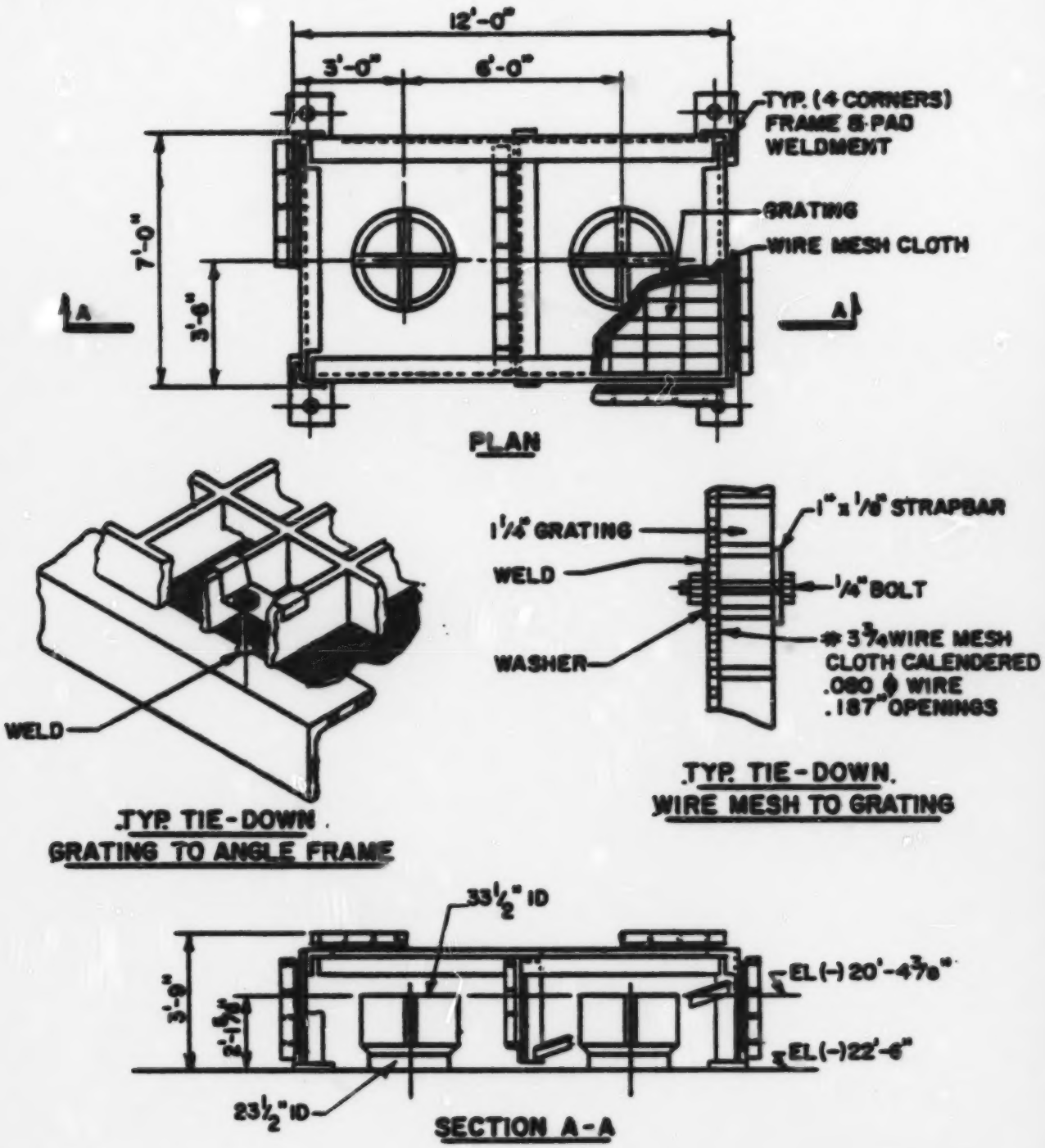

Sump Screen Area 198 ft^2
Min. Containment Building Depth after LOCA Elev. 18'-2"

Figure B-3. Containment Sump, Millstone Unit 2

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APPENDIX C
ST. LUCIE NO. 1

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 777 MWe, Combustion Engineering, PWR St. Lucie No. 1 which started commercial operation in 1975.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the emergency intake sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump

3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break.

Calcium silicate block has been used almost exclusively within the containment. However, the reactor coolant pump and some removable insulation sections on piping use reflective metallic.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, emergency drainage and insulation details for St. Lucie No. 1.

1. Documentation

Letter from Florida Power and Light Company to the NRC dated March 16, 1981 on containment sump and insulation information.

2. Drawings

a. Equipment and General Arrangement

8770-G-065	General Arrangement Reactor Building Floor Plans Sh. 1
8770-G-066	General Arrangement Reactor Building Floor Plans Sh. 2
8770-G-067	General Arrangement Reactor Building Sections Sh. 1
8770-G-068	General Arrangement Reactor Building Sections Sh. 2
8770-G-226	Reactor Building Instrument Arrangement Sh. 1 and 2 of 2

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of systems inside the reactor containment containing insulation. The list includes the system, and the type of insulation used for each system.

System	Type of Insulation
Safety Injection	Encapsulated Calcium Silicate
Pressurizer Surge Line	Encapsulated Calcium Silicate
Reactor Coolant	Encapsulated Calcium Silicate
Pressurizer Spray Line	Encapsulated Calcium Silicate
Shutdown Cooling	Encapsulated Calcium Silicate
Feedwater	Encapsulated Calcium Silicate
Emergency Feedwater	Encapsulated Calcium Silicate
Pressurizer Safety Relief Valves to Quench Tank	Encapsulated Calcium Silicate
Main Steam	Encapsulated Calcium Silicate
Equipment Inside Primary Containment	
Reactor Coolant Pumps	Reflective Metallic
Steam Generators	Encapsulated Calcium Silicate
Pressurizer	Encapsulated Calcium Silicate
Reactor Vessel	Encapsulated Calcium Silicate

D. TYPICAL INSULATION DETAILS

For lines subjected to inservice inspection, the reflective and conventional metal panels which come equipped with buckles for ease of disassembly were used. These lines are insulated with either metal jacketed calcium silicate with removable reflective metal panels at weld joints or metal jacketed calcium silicate with removable conventional panels at weld joints. For the remaining lines, metal jacketed calcium silicate block insulation is used. The block insulation halves are wired together then covered with metal lagging which is riveted or bonded. The steam generators, pressurizer, regenerative heat exchanger and reactor vessel were insulated with metal jacketed calcium silicate with removable reflective metal panels at weld joints.

The reactor coolant pump is insulated with reflective insulation which is fully removable.

E. PIPE BREAK LOCATIONS

None were provided.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTION

None were provided.

G. PRELIMINARY INSULATION DEBRIS HAZARDS ANALYSIS

Figures C-1 and C-2 are simplified sketches of the St. Lucie Unit 1 reactor containment. The reactor vessel, steam generators, pressurizers and associated piping are all located inside the shield wall. The safety injection tanks are located outside the shield wall. The emergency sump is located outside the shield wall in a trench surrounding the shield wall. The location of the emergency sump within the trench is shown in Figure C-2. Figure C-3 and C-4 show the details of the emergency sump. The trench floor is at El. 12 ft. and the sump pit floor is at El. 7'-7". The trench and sump pit are covered by grating at El. 23'. From outside the shield wall a stairway leads down into this trench to a passage through the shield wall and a stairway up to the steam generator cavity floor. Drainage trenches in the cavity pass through the shield wall and drain into the outer trench. These trenches are covered by grating with the outer trench draining into the sump pit. The entrance to the sump pit has a screen door. Within the pit, the two intakes are covered by obelisk screen structure over each individual intake.

For a pipe break outside the shield wall, the potential for a large amount of insulation to migrate towards the sump does not exist. Several floors, either partial or complete, exit outside the shield wall and would catch most of the insulation. However, a small amount of insulation could migrate down the stairwells and other openings.

For a pipe break inside the shield wall, the potential for a large amount of insulation to migrate towards the sump may exist. It may be possible for insulation to pass down through the access stairways and reach both the outer annulus and the outer trench.

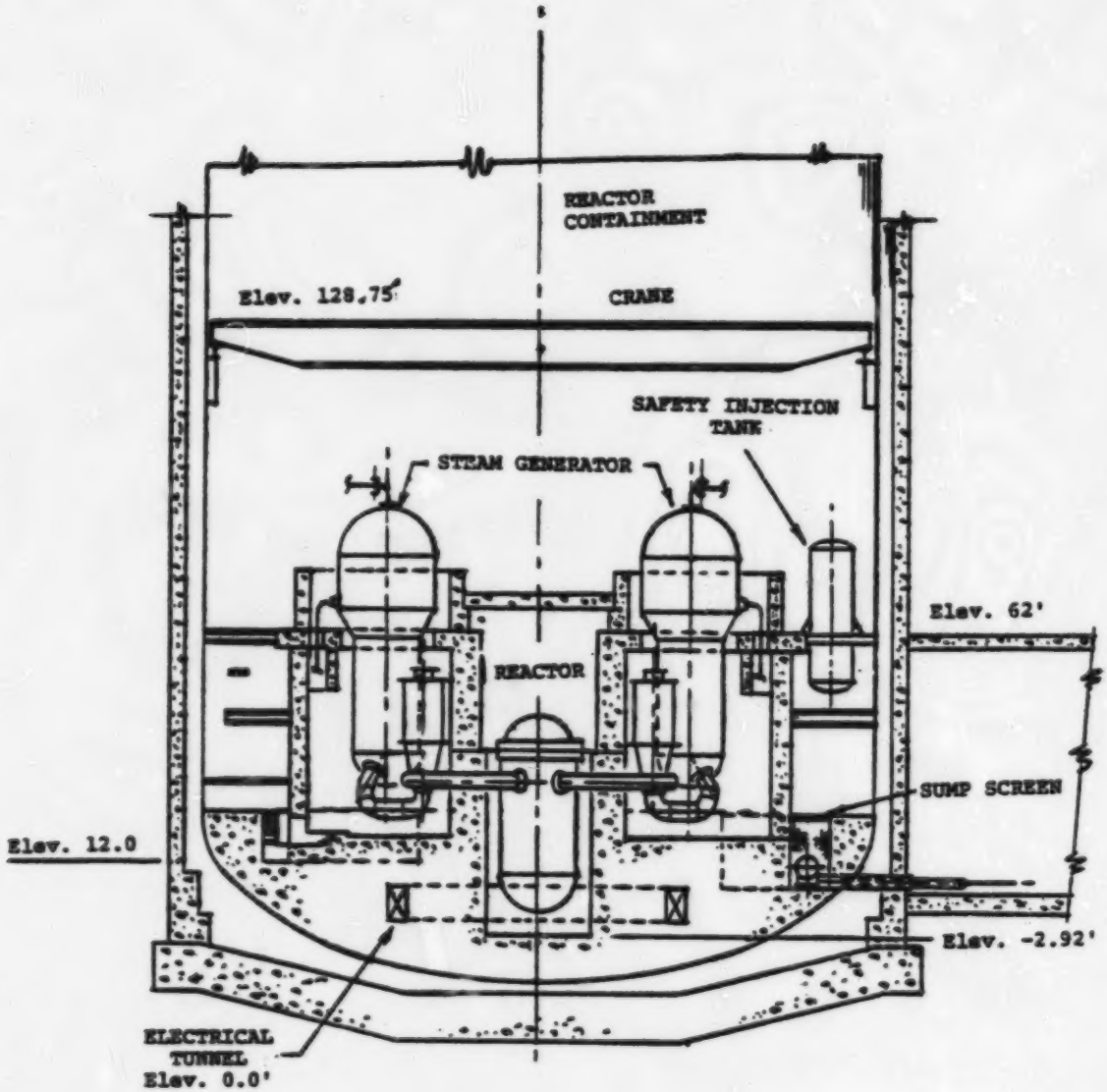

Figure C-1. Reactor Building Elevation,
St. Lucie Unit 1

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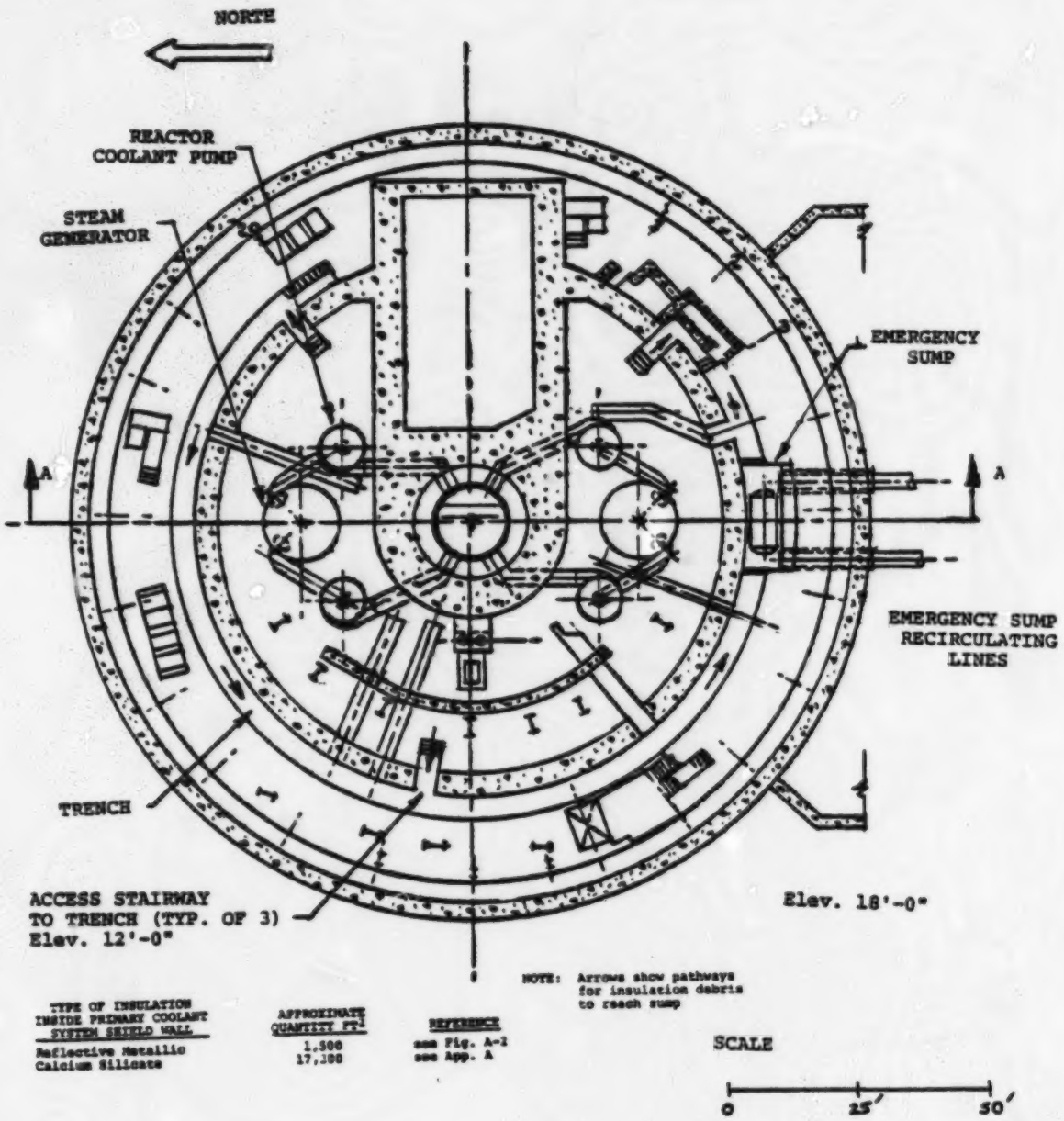

Figure C-2. Reactor Building Plan,
St. Lucie Unit 1

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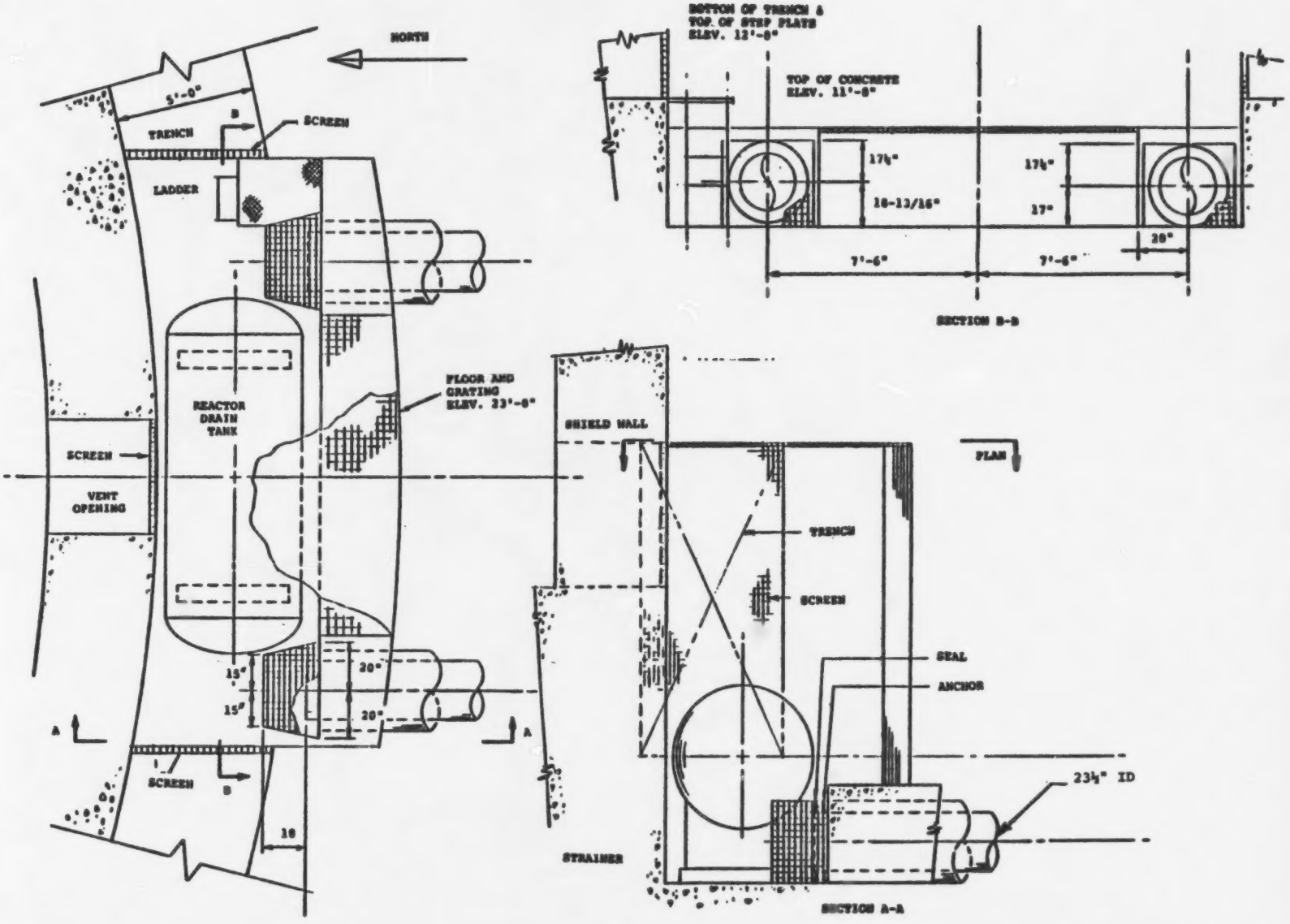

Figure C-3. Containment Sump, St. Lucie Unit 1

Sump Screen Area 266 ft^2
Min. Containment Building Water Depth after LOCA Elev. 20'

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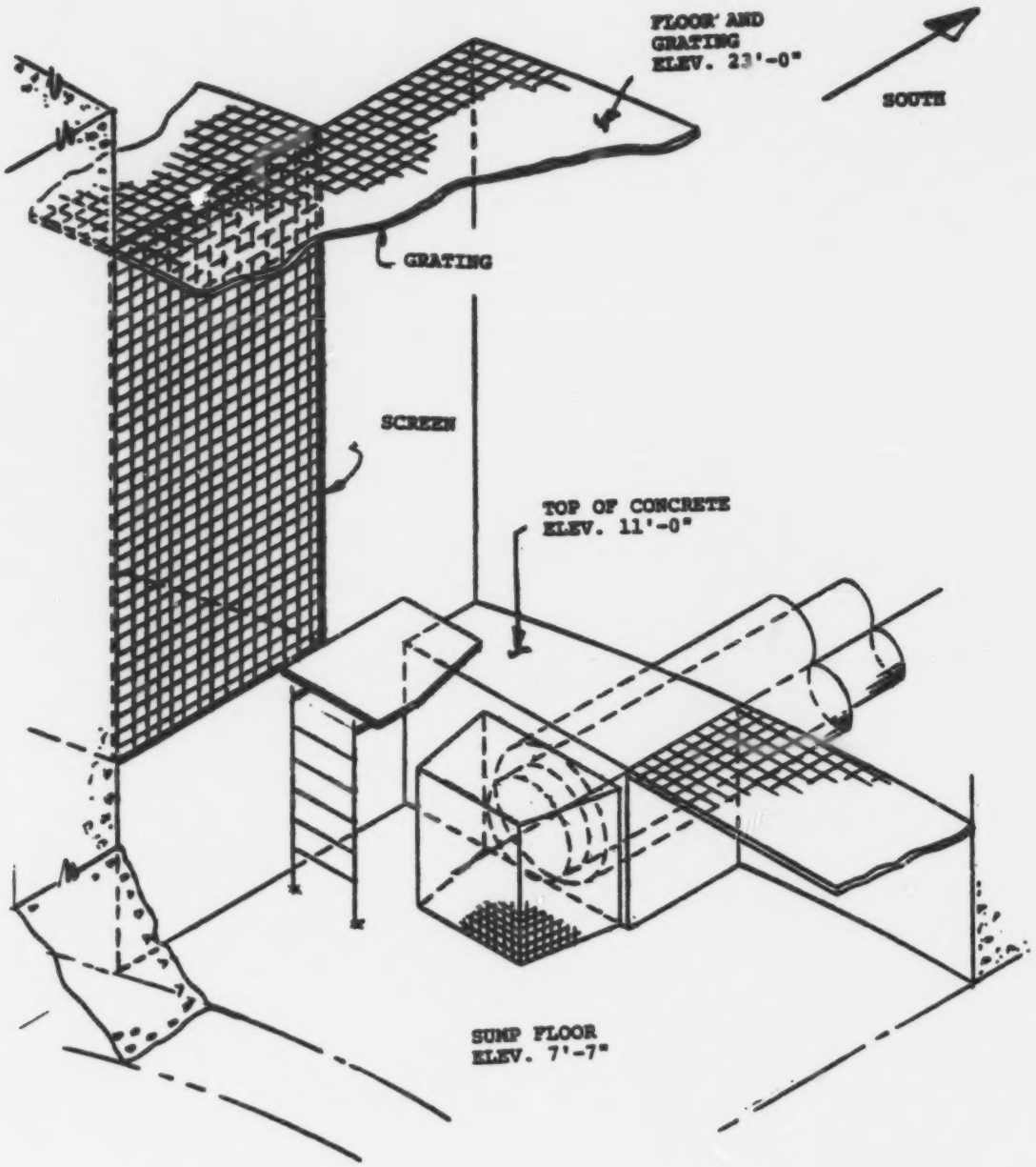

Figure C-4. Containment Sump Isometric,
St. Lucie Unit 1

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APPENDIX D
CALVERT CLIFFS 1 & 2

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the twin 850 MWe, Combustion Engineering, PWR, Calvert Cliffs 1 & 2 which went into commercial operation in 1975 and 1977.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the recirculation intake sump

3. Details of the insulation that could be dislodged and become a source of debris as the result of a major break.

Stainless steel, all metal reflective insulation as manufactured by Transco is used for the reactor coolant piping system, reactor vessel, steam generators, and reactor cavity.

Stainless steel encapsulated mineral wool is used on reactor coolant pumps, steam generators, regenerative heat exchanger, and reactor dome. The pressurizer is covered by both reflective metallic and stainless steel encapsulated mineral wool.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, emergency drainage and sump details, piping flow diagrams and equipment general arrangement drawing obtained from Baltimore Gas and Electric.

1. Documentation

   a. Letter dated 4/22/81 from BG&E Principal Engineer Olson to Clark, Chief, Operating Reactors Branch #3 with attached TABLE 1 Insulated Equipment in Containment

   b. Letter dated 3/3/81 from Principal Engineer Olson to Clark, Chief, Operating Reactors Branch #3 with attached responses to insulation query including Specification for Plant Insulation - except Reactor Cavity Insulation, Reactor Coolant System and Steam Generators Insulation. Attached are six sheets showing Emergency Sump Location and Details.

   c. Transmittal letter dated 7/14/81 from Baltimore Gas & Electric Engineer Gahan to Riddington B&R which included

Containment 1 & 2 piping drawings, original insulation specifications for high energy piping and systems, M-336, M-338, and M-339; along with piping summary sheets M-601.

d. Transmittal letter dated 7/15/81 from BG&E Engineer Gahan to Riddington detailing submitted equipment arrangement drawings in containments 1 & 2 (17 drawings in all).

2. Drawings

a. Equipment and General Arrangment Containment

60-217-E	Equipment Location Containment and Auxiliary Building Unit 1 Section E-E
60-215-E	Equipment Location Containment and Auxiliary Building Unit 1 Section A-A
60-215-E	Equipment Location Containment and Auxiliary Building Plan El. 5'-0" & 10'-0"
60-203-E	Equipment Location Containment and Auxiliary Building Plan El. 27'-0"
60-204-E	Equipment Location Containment and Auxiliary Building Plan El. 45'-0"
60-205-E	Equipment Location Containment and Auxiliary Building Plan El. 69'-0"
62-202-E	Equipment Location Containment and Auxiliary Building Unit 2 Plan El. 5'0" & 10'-0"
62-203-E	Equipment Location Containment and Auxiliary Building Unit 2 Plan El. 27'-0"
62-204-E	Equipment Location Containment and Auxiliary Building Unit 2 Plan El. 45'-0"
62-205-E	Equipment Location Containment and Auxiliary Building Unit 2 Plan El. 69'-0"

62-217-E	Equipment Location Containment and Auxiliary Building Unit 2 Section F-F
62-215-E	Equipment Location Containment and Auxiliary Building Unit 1 Section C-C
61-756-E	Containment Interior Plan @ El. 10'0" Units 1 & 2
61-757-E	Containment Interior Plan @ El. 29'-6" Units 1 & 2
61-758-E	Containment Interior Plan @ El. 37'-4" Units 1 & 2
61-759-E	Containment Interior Plan @ El. 45'-0" Units 1 & 2
61-760-E	Containment Interior Plan @ El. 69'-0" Units 1 & 2

b. Emergency Sump Design Details

Selected sump design details selected photo copied sections of the following drawings:

Bechtel Drawings Nos.

M-132 Rev. 9

M-137 Rev. 9

M-136 Rev. 5

C-256 Rev. 8 (2 sheets)

M-565 Rev. 5

c. Flow Diagrams for Insulated Systems in Containment

None were provided.

d. Piping Layout Drawings

60-E463-E	Area No. 23 Piping Plan El. 69'-0"
60-462-E	Area No. 23 Piping Plan El. 45'-0"

60-461-E	Area No. 23 Piping Plan El. 27'-0"
60-460-E	Area No. 23 Piping Plan El. 10'-0"
60-457-E	Area No. 22 and 23 Piping Sections and Details
60-456-E	Area No. 22 and 23 Piping Sections and Details
60-455-E	Area No. 22 and 23 Section "B-B"
60-454-E	Area No. 22 and 23 Section "A-A"
60-453-E	Area No. 22 and 23 Piping Plan El. 69'-0"
60-452-E	Area No. 22 Piping Plan El. 45'-0"
60-451-E	Area No. 22 Piping Plan El. 27'-0"
60-450-E	Area No. 22 Piping Plan El. 10'-0"
60-463-E	Area No. 25 Piping Plan El. 69'-0"
60-462-E	Area No. 25 Piping Plan El. 45'-0"
60-461-E	Area No. 25 Piping Plan El. 27'-0"
60-460-E	Area No. 25 Piping Plan El. 10'0"
60-457-E	Area No. 24 and 25 Piping Sections and Details
60-456-E	Area No. 24 and 25 Piping Sections and Details
60-455-E	Area No. 24 and 25 Piping Section "B-B"
60-454-E	Area No. 24 and 25 Piping Section "A-A"
60-453-E	Area No. 24 Piping Plan El. 69'0"

60-452-E	Area No. 24 Piping Plan El. 45'-0"
60-451-E	Area No. 24 Piping Plan El. 27'-0"
60-450-E	Area No. 24 Piping Plan El. 10'-0"

e. Insulation Drawings

None submitted.

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of systems inside the reactor containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Size (inches)	Type of Insulation
Pressurizer Surge Line	12-3/4	Reflective
Coolant Loops	49-3/4,35-1/4	Reflective
Letdown Line	2	Encapsulated
Safety Injection	12,6	Encapsulated
Charging	2	Encapsulated
RCS Auxiliary Piping	3/4	Encapsulated
RCS Vents & Drains	2	Encapsulated
Pressurizer Spray	3,2	Encapsulated
Reactor Coolant Pump Bleed	3/4	Encapsulated
Shutdown Cooling	12	Mineral Wool
RCS Pressure End	3/4	Mineral Wool
Equipment Inside/ Primary Containment		
Reactor Coolant Pumps		Encapsulated
Steam Generators		Reflective, Encapsulated
Regenerative Heat Exchanger		Encapsulated
Pressurizer		Reflective, Encapsulated
Reactor Vessel		Reflective
Reactor Dome		Encapsulated
Reactor Cavity		Reflective

D. TYPICAL INSULATION DETAILS

Reflective metallic insulation is used exclusively for the reactor cavity reactor vessel and primary coolant loops. The insulation used for piping is typically two feet or longer in length, 3-4 inches thick and split in two sections with each section covering half the pipe. These sections have 24 gauge stainless steel outer sheets which enclose nine or ten 2 mil stainless steel foil sheets. The inner sheets are built up about three sheets per inch of insulation with the innermost sheet enclosing the foil 22 gauge stainless steel. End closures are 26 gauge stainless steel.

Reflective panels generally consist of 22 gauge stainless steel 9 or 10 sheets on 2 mil stainless steel foil and outer sheet of 24 gauge stainless steel. Most panels are reinforced using a stainless steel nail fixed through the section.

Insulation panels and sections are attached to equipment insulation support frames or angles and to piping using combinations of C-clips, Z-clips, interlapping panels, and quick release buckles. Some reactor vessel insulation is permanently attached using self tapping screws.

Mineral wool panels, which are used exclusively or in combination with reflective metallic on reactor coolant pumps, steam generators, regenerative heat exchangers, pressurizer, reactor dome, and all non-primary coolant piping, are of similar outer construction to reflective metallic. The panels consist of 22 gauge stainless steel sheet, a thickness of 9 pound density mineral wool, and a 24 gauge stainless steel sheet. End closures are 26 gauge stainless steel. There is some variation in gauge of stainless steel sheeting used to enclose the mineral wool panel on the reactor dome, 18 and 22 gauge stainless steel is used. Also variation in density thickness is possible.

Mineral wool panels are attached in the same manner as that outlined for the reflective metallic.

E. PIPE BREAK LOCATIONS

Not developed for Calvert Cliffs Unit No. 1 & 2.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Baltimore Gas and Electric.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures D-1 and D-2 are simplified sketches of the Calvert Cliffs Unit No. 1 Reactor Containment Building. The reactor vessel, steam generators, reactor coolant pumps, pressurizer, and associated piping are located inside the shield wall. Figure D-2 shows the location of the emergency sump on floor of the containment building at an eleva-

tion of 11'. Figure D-3 shows the details of the emergency sump. The sump adjoins the reactor building sump and the two sumps are separated by a 1/4" thick steel plate with 1/2 inch diameter holes drilled in the bottom. The screen surrounding the sump is constructed with beams and covered with stainless steel grating. Clipped to the inside of the grating is a 2-3/4" mesh stainless steel wire cloth, .120 inch diameter.

For a pipe break inside the shield wall, the potential for a large amount of insulation to migrate towards the sump is very small. A concrete and grate floor exists at El. 31' and would catch most of the insulation. Similarly, for a pipe break outside the shield wall, the potential problem is small. A floor existing at El. 45' would catch most of the insulation. However, a small amount of insulation could migrate down the stairwells and other openings.

For a pipe break inside the shield wall below the floor at El. 31' or outside the shield wall below the floor at El. 45', insulation can migrate to the sump. The sump has some small diameter (2 to 4 inches) pipe passing over it. Insulation from this pipe could fall onto the sump. The reflective metallic would sink to the floor while the encapsulated mineral wool would float and then sink after it became saturated with water.

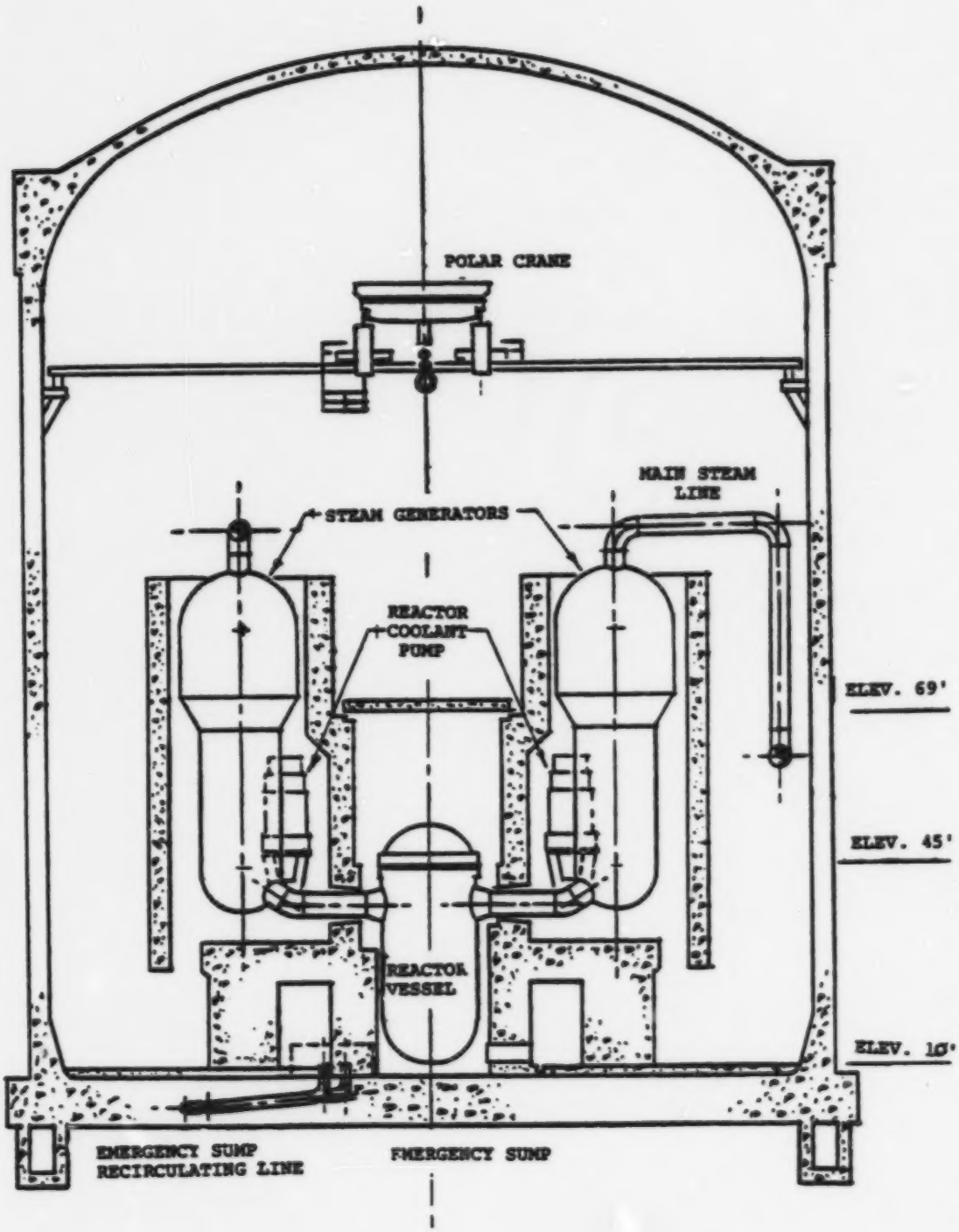

Figure D-1. Reactor Building Elevation, Calvert Cliffs, Units 1 and 2

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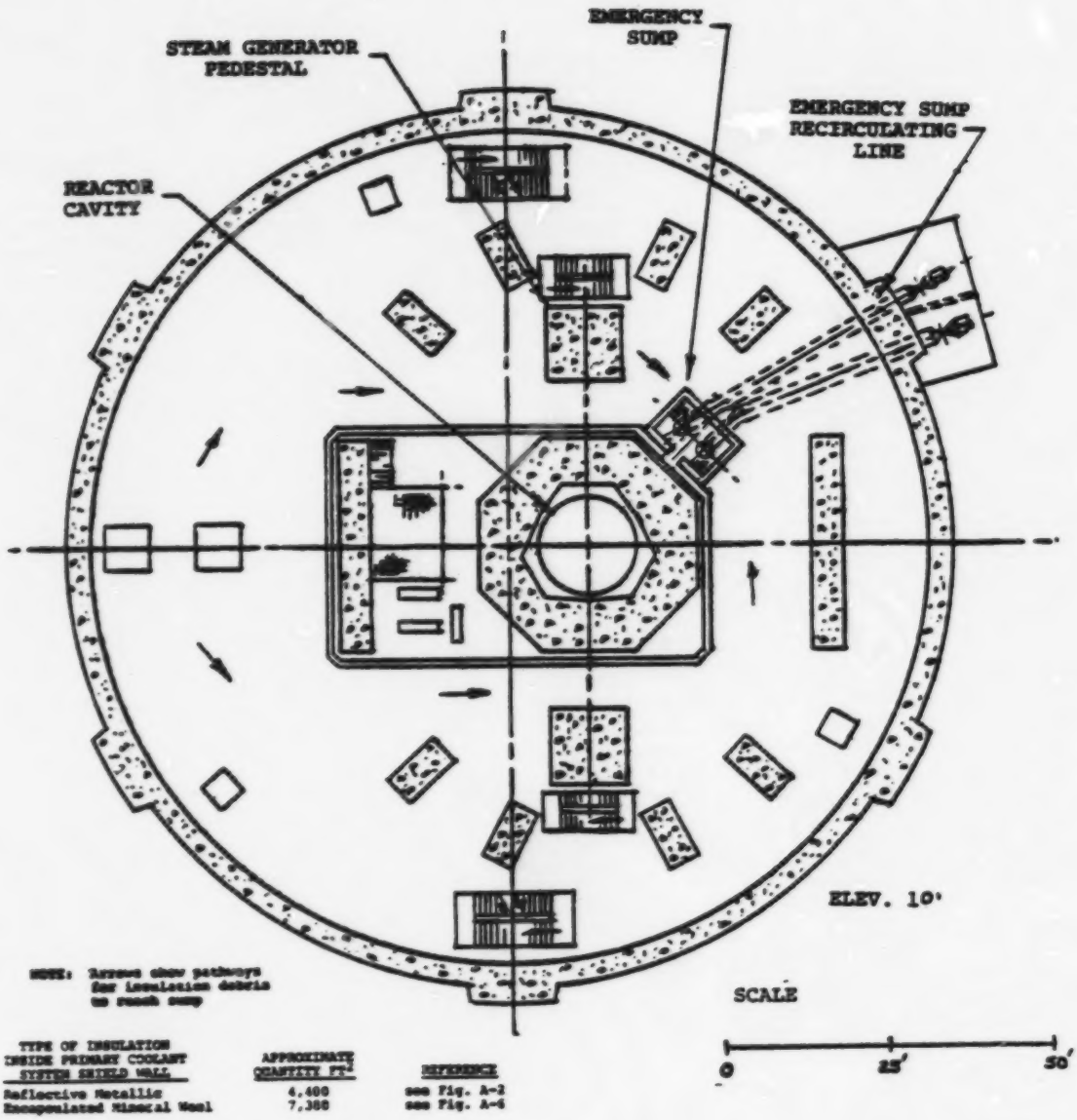

Figure D-2. Reactor Building Plan, Calvert Cliffs, Units 1 and 2

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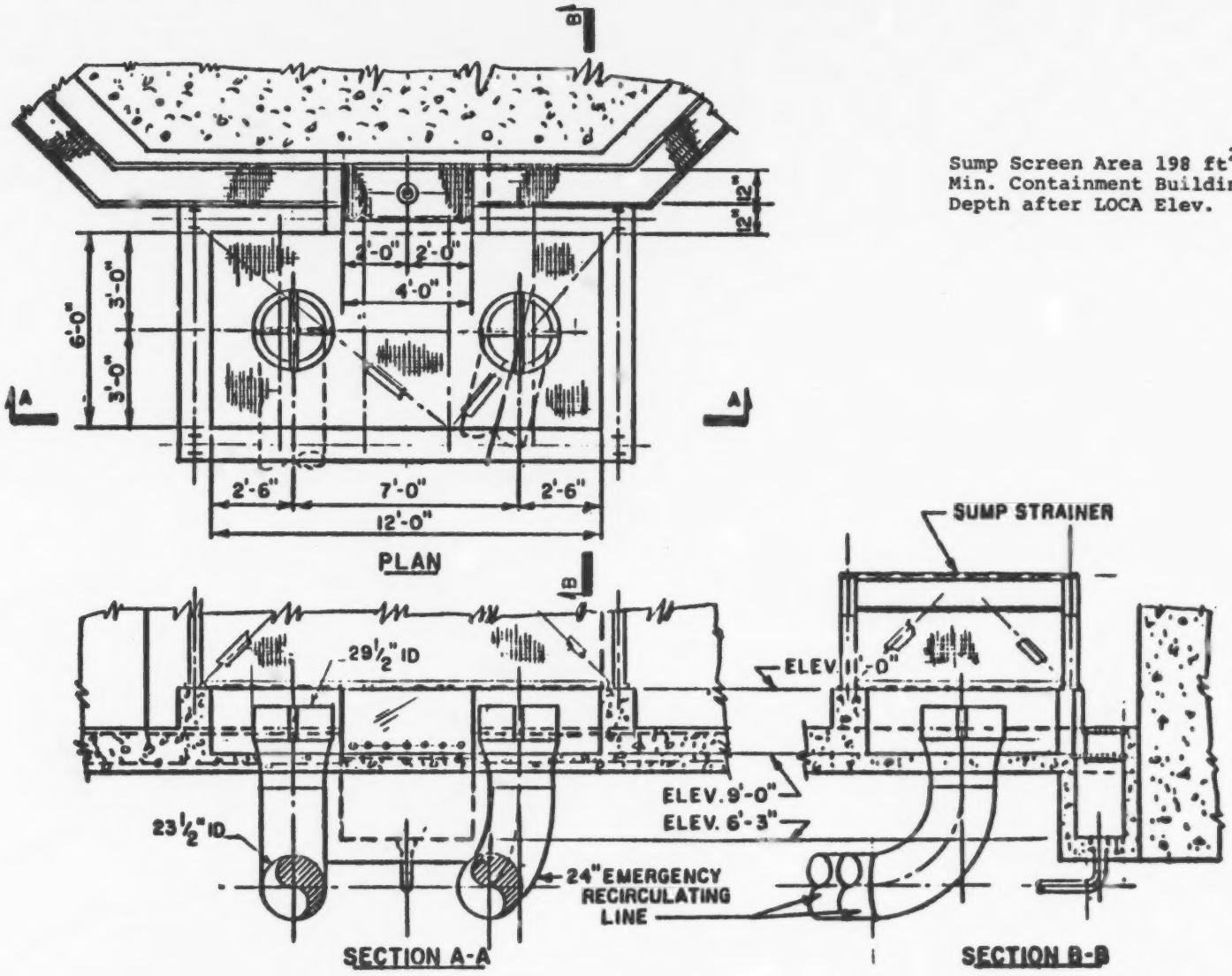

Figure D-3. Containment Sump, Calvert Cliffs Units 1 and 2

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APPENDIX E
ROBERT EMMETT GINNA UNIT 1

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 490 MWe Westinghouse PWR, Robert Emmett Ginna Nuclear Power Plant, Unit No. 1 which commenced commercial operation in 1969.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment building including high energy fluid piping

2. The location and configuration of the sump for emergency core cooling, and the communication paths by which debris generated by a major pipe break could reach the emergency recirculation sump

3. Details of the insulation that could be dislodged and become a source of debris as a result of a major pipe break.

According to information supplied by Rochester Gas and Electric Corp. (RG&E), Kaylo (hydrous calcium silicate) and Kaylo-20, manufactured by Johns-Manville, are used to insulate most of the piping system in containment. Vinycel, also manufactured by Johns-Manville, is used to insulate the interior of the containment building wall and all equipment insulated inside containment is insulated with Johns-Manville Kaylo block and bonding cement.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of the reactor building's piping system, equipment, and insulation.

1. Documentation

   a. Docket No. 50244. Letter dated March 4, 1981 from John E. Maier, Vice President, RG&E to Mr. Dennis M. Crutchfield, Chief Operating Reactors Branch No. 5, NRC, titled Information Request Regarding Containment Sumps and Insulation for Operating Reactors.

2. Drawings

   a. General Arrangement - Reactor Containment

D-001-012	Plan Above Basement Floor
D-421-001	Reactor Containment Vessel, Mat Foundation, Elev. 233'-8" and Ring Girder

D-421-003	Reactor Containment Vessel, Basement Floor Slab Elev. 235'-8"
D-421-009	Reactor Containment Vessel, Basement Floor Dowel and Anchor Bolt Location

b. Emergency Sump Design Details

D-421-002	Reactor Containment Vessel, Mat Foundation, Elev. 233'-8", Reinforcement and Details

c. Piping Diagrams for Inside Containment

D-304-014	Main Steam Plan (in Containment)
D-304-083	Feedwater Pump Suction & Discharge Plan
D-304-084	Feedwater Pump Suction & Discharge Sections
D-304-122	Steam Generators Blowdown Lines, Plan & Sections - Misc.
D-304-193	Chemical Cleaning, Containment Vessel & Int. Building
D-304-601	Reactor Coolant Primary Loops
D-304-602	Plan, Pressurizer Relief & Spray Piping
D-304-603	Sections, Pressurizer Relief & Spray Piping
D-304-604	Reactor Coolant System Misc., Plans & Sections
D-304-611	Plan, Residual Heat & Safety Injection
D-304-612	Sections, Residual Heat & Safety Injection
D-304-613	Plan, Auxiliary Cooling Water - Misc.
D-304-614	Sections, Auxiliary Cooling Water - Misc.
D-304-618	Plan R.V. Support Clg. & R.C. Pump Coolant

D-304-619	Sections, R.V. Support Clg. & R.C. Pump Coolant
D-304-630	Plan & Sections, Misc. Above Elev. 253'-0" Inside Containment
D-304-631	Chemical and Volume Control System - Misc. Plan
D-304-632	Chemical and Volume Control System - Misc. Sections
D-304-641	Containment Spray, Plan & Sections Above 274'-6" & 278'-4"
D-304-642	Safety Injection & Containment Spray Plan Below Elev. 274'-6" & Elev. 278'-4"
D-304-643	Safety Injection & Containment Spray Sections
D-304-645	Safety Injection System Plan & Misc. Sections
B-326-004	Piping Detail, 8" Suction Line From Containment Sump "B" to Residual Heat Pumps, 4' Reactor Drain Pump Suction

d. Insulation Drawings

None were provided.

e. Reactor Building Platform Drawings

None were provided.

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of piping systems and equipment inside primary containment containing insulation. The list includes the system, equipment, nominal pipe sizes, and type of insulation used for each system. The relationship between systems and equipment, and insulation were figured based on information provided the NRC.

System	Nominal Pipe Size (inches)	Type of Insulation
Safety Injection	4, 6, 10	Calcium Silicate
Pressurizer Surge Line	6	Calcium Silicate
Reactor Coolant System	29, 31	Calcium Silicate
Pressurizer Spray Line	3	Calcium Silicate
Shutdown Cooling	6, 10	Calcium Silicate
Feedwater	14	Calcium Silicate
Emergency Feedwater	4	Calcium Silicate
Pressurizer Safety Relief Valves to Quench Tank	8	Blanket
Main Steam	30	Calcium Silicate
Chilled Water	2, 1, 1-1/2	Fiberglass
Equipment Inside Primary Containment		
Reactor Vessel		Calcium Silicate
Reactor Coolant Pump		Calcium Silicate
Pressurizer		Calcium Silicate
CVCS Regenerative Heat Exchanger		Calcium Silicate
Steam Generator		Calcium Silicate

D. TYPICAL INSULATION DETAILS

The containment building walls are insulated with Johns-Manville Vinycel insulation sheets measuring 44" x 84" x 1-1/4". Each sheet is covered with 019 ga. type 304 stainless steel.

The piping system inside containment is mostly insulated with Johns-Manville Kaylo (hydrous calcium silicate) and Kaylo-20 with densities of 11 and 12 lb/ft^3, respectively. Also used in insulating the system was Johns-Manville's thermobestos and Pittsburgh-Corning's Unibestos both of which are currently being replaced by Johns-Manville's Thermo-12 (hydrous calcium silicate). The density of Thermo-12 is 13 lb/ft^3.

At points in piping runs where insulation is anticipated to be occasionally removed, insulation blankets were used. Blankets that were installed were Eastern Refractories Company, Inc. Erco Mat. (ceramic glass fiber) of 15 lb/ft^3, Clairmont Supply Co., Claremat 1200 (mechanically bonded glass fiber) of 15 lb/ft^3, and J. P. Stevan's Tent-Mat. A small amount of Johns-Manville's Micro-Lok 650 (fiber glass) was installed on the service water piping to the reactor compartment cooling system.

All the insulation on the piping system is attached with stainless steel wire. Mineral fiber bonding cements have been used inside containment on valves and other irregular shaped components requiring insulation. All piping insulation, except the Micro-Lok 650, is jacketed with .010" ga 304 stainless steel and seams are pop-riveted. All equipment insulated inside containment is insulated with Johns-Manville Kaylo block and bonding cement and is jacketed with .020" ga stainless steel.

E. PIPE BREAK LOCATIONS

Not developed for R. E. Ginna Unit No. 1.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Rochester Gas and Electric.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures E-1 and E-2 are simplified sketches of the Robert E. Ginna reactor containment. The reactor vessel, steam generators, pressurizer, and associated piping are all located inside the shield wall. The location of the emergency sump just below part of the shield wall and the reactor refueling channel at El. 235'-8" is shown in Figure E-2. Figure E-3 shows the details of the emergency intake sump. The sump in plain view is a trapezoidal opening in the floor covered stainless steel grating. The tank and two intake pipes within the 8-1/2' deep sump are separated by a 1-1/2" grating.

For a pipe break outside the shield wall, the potential for a large amount of insulation to migrate towards the sump does not exist. A concrete and grate floor exists at El. 253'-3", and would catch most of the insulation. However, a small amount of insulation could migrate down the stairwells and other openings.

For a pipe break inside the shield wall, the potential for a large amount of insulation to migrate towards the sump is greater than the outside case. There exists a number of platforms within the region which would catch some of the insulation before it reaches the containment floor. Once on the basement floor level, the calcium silicate will float while the asbestos and glass fiber blanket will also initially float. This insulation could be transported to the emergency sump, and the calcium silicate and glass fiber blanket could sink at the sump.

Below the floor at El. 253'-3", there exist numerous pipes and equipment in the immediate vicinity of the sump. The largest item in this region is the pressurizer relief tank. A pipe break in the region could result in large quantities of insulation around the sump.

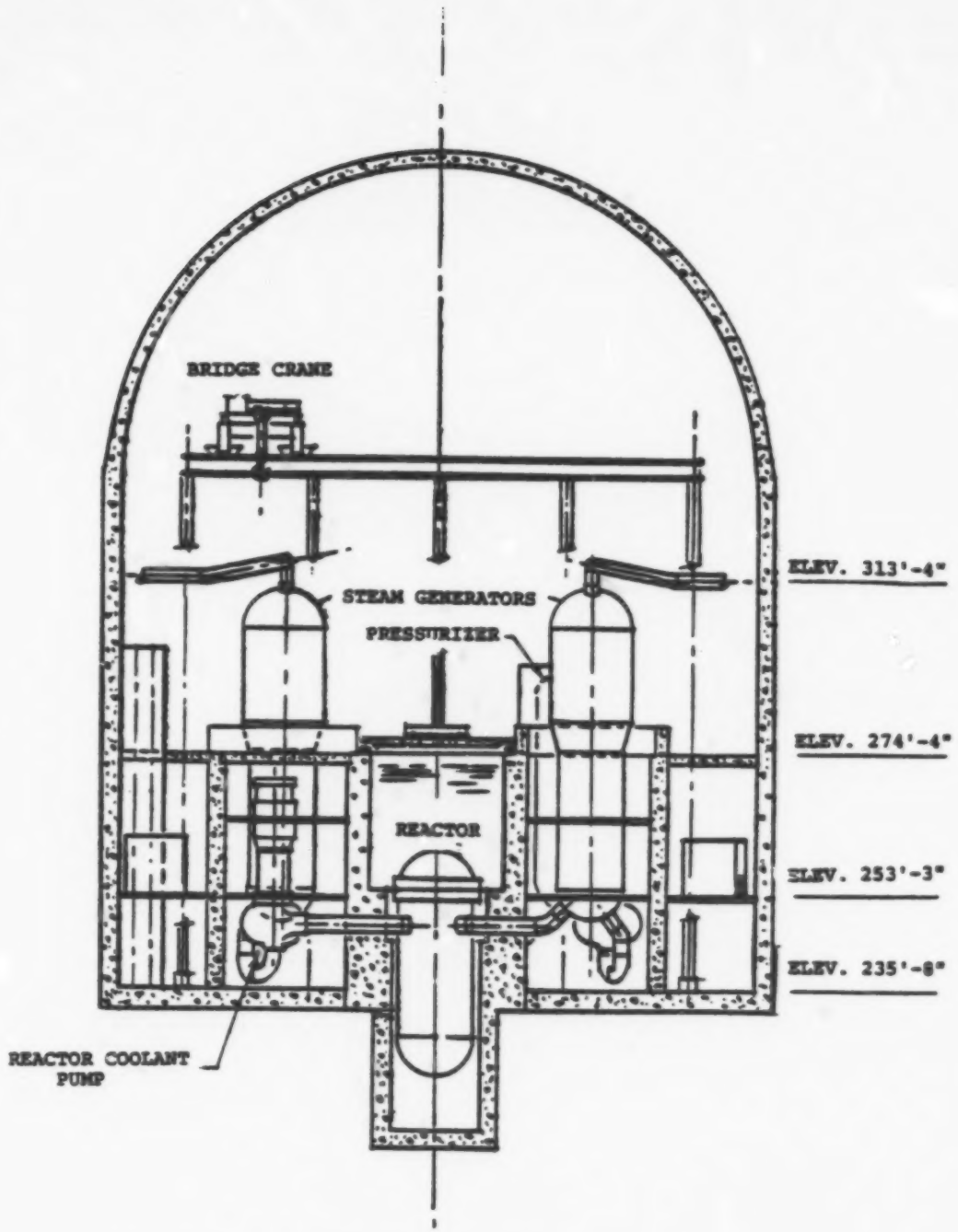

Figure E-1. Reactor Building Elevation,
Robert E. Ginna

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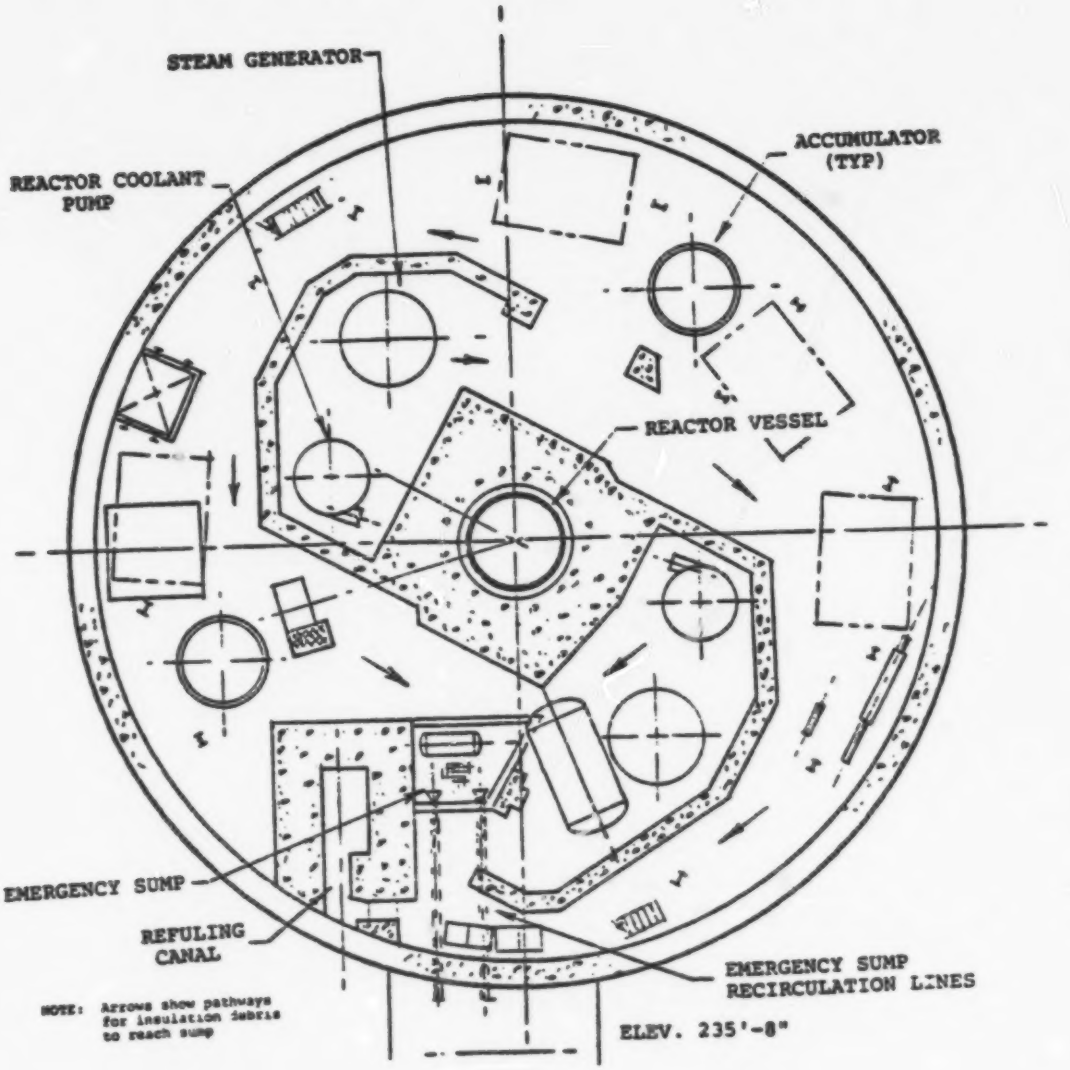

TYPE OF INSULATION INSIDE PRIMARY COOLANT SYSTEM SHIELD WALL	APPROXIMATE QUANTITY FT³	REFERENCE
Calcium Silicate	22,300	see Fig. A-6
Thermobestos*	3,400	see Fig. A-6
Mineral Glass Blankets	1,000	see App. A

*Being replaced with calcium silicate

Figure E-2. Reactor Building Plan, Robert E. Ginna

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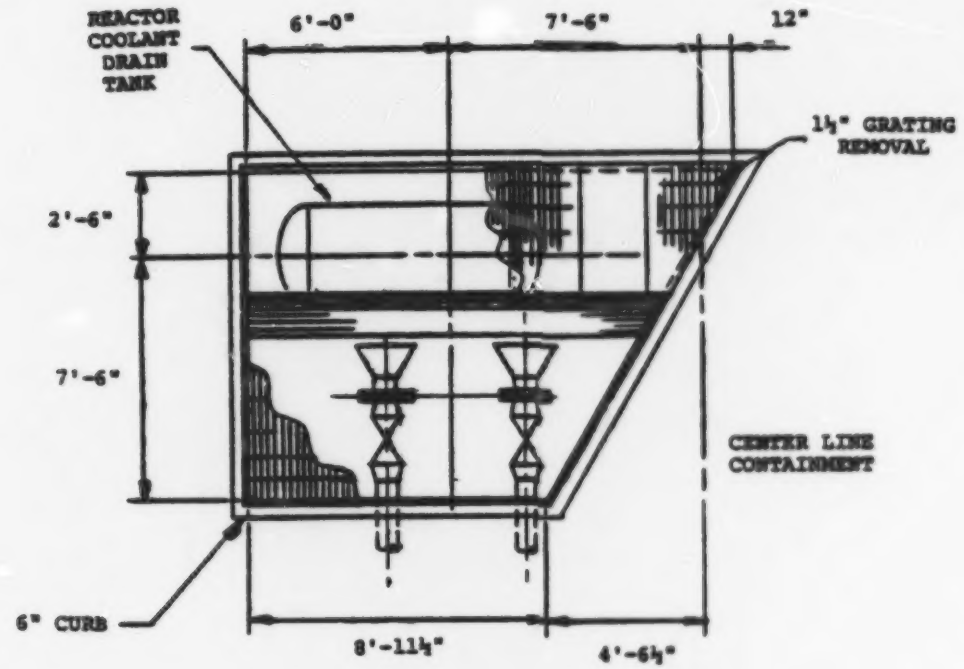

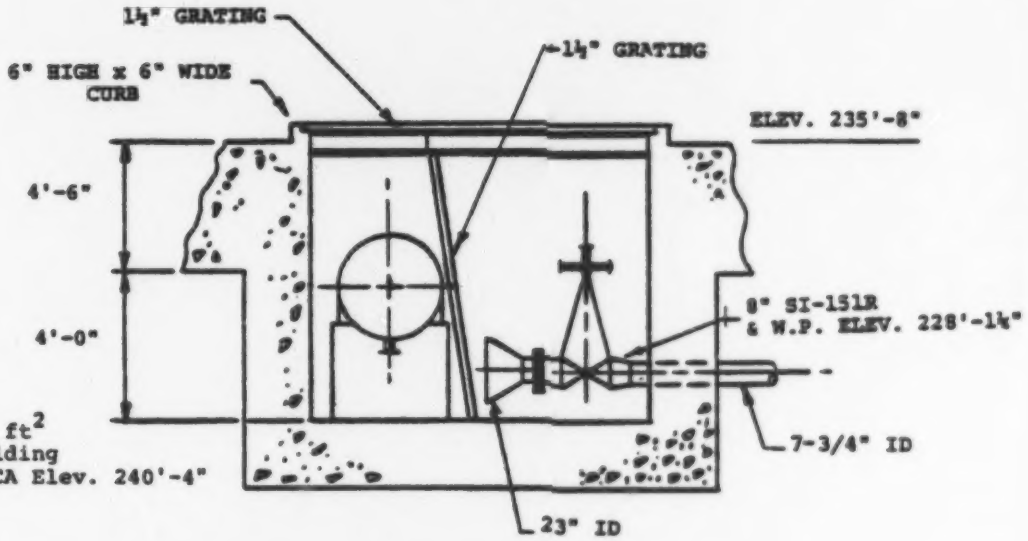

Sump Screen Area 142 ft^2
Min. Containment Building
Water Depth after LOCA Elev. 240'-4"

Figure E-3. Containment Sump,
Robert E. Ginna

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APPENDIX F
PRAIRIE ISLAND UNITS 1 & 2

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 520 MWe, Westinghouse, PWR, Prairie Island Nuclear Station. Unit 1 started commercial operation in 1973 and Unit 2 startd commercial operation in 1974.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the emergency intake sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency rcirculating sump

3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break.

Reflective metallic insulation is used throughout the plant for all equipment and piping except for pipe hangers and restraints. Pipe hangers and restraints are covered with fibrous glass insulation.

B. LISTING OF INPUT DRAWING AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, piping, flow diagrams, emergency sump details and insulation details obtained from Northern States Power Company.

1. Documentation

   a. Letter from Northern States Power Company to NRC dated January 7, 1981 on the containment sump and thermal insulation information.

2. Drawings

   a. Emergency Sump Details

NF-38407P	Reactor Building El. 697'-6"	Unit 1
NF-38486-3H	Concrete Sections & Details	Unit 2

   b. Piping Layout Drawing

NF-39334-1	Residual Heat Removal Piping	Unit 1
NF-39334-2L	Residual Heat Removal Piping	Unit 2

NF-39350-1F	Reactor Building Composite Piping Unit 1
NF-39357-1	Floor Plan El. 697'-6" Unit 2
NF-39350-5	Reactor Building Composite Piping Unit 1
NF-39357-5	Section A-A Unit 2
NF-39350-8D	Reactor Building Composite Piping Section D-D Unit 1
NF-39357-6B	Reactor Building Composite Piping Section B-B Unit 2
NF-39357-7B	Reactor Building Composite Piping Section C-C & D-D Unit 2
NF-39351-4G	Reactor Building Floor Unit 1
NF-39358-4D	Drain Piping El. 697'-6" Unit 2

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the equipment and systems inside primary containment containing insulation. The list includes the equipment, the system, nominal pipe sizes inside containment and the type of insulation used for each system.

System	Nominal Pipe Size (inches)	Type of Insulation
Safety Injection	10, 12	Reflective Metallic
Pressurizer Surge Line	10	Reflective Metallic
Reactor Coolant	36	Reflective Metallic
Pressurizer Spray Line	3	Reflective Metallic
Shutdown Cooling	8, 10	Reflective Metallic
Feedwater	16	Reflective Metallic
Emergency Feedwater	8	Reflective Metallic
Pressurizer Safety Relief Valves to Quench Tank	10, 6, 4, 3	Reflective Metallic
Main Steam	30	Reflective Metallic

Equipment Inside
Primary Containment

Reactor Vessel	Reflective Metallic
Steam Generator	Reflective Metallic
Reactor Coolant Pump	Reflective Metallic
Pressurizer	Reflective Metallic
Main Steam & Feedwater Pipe Hangers & Restraints	Fibrous Glass Blanket

D. TYPICAL INSULATION DETAILS

The reflective metallic insulation used for equipment and piping inside containment is described in Appendix A of this report. Two insulation contractors are Mirror Insulation, a unit of Diamond Power Specialty Company and Transco, Inc., a unit of Universal Fabricated Products. The insulation material used for the reflective insulation is all stainless steel.

The fibrous glass insulation used for the main steam and feedwater pipe hanger and restraints inside containment is similar to the mineral fiber insulation described in Appendix A of this report. The fibrous glass insulation consists of three one-inch thick Temp Mat manufactured by Pittsburgh Corning between two 1000° glass cloth cover, CS 9383 style 1925 manufactured by Clark Schwedel Insulation. The Temp Mat has a bulk density of 11.25 lb/ft^3. The three layers are held together using 18 gauge stainless steel wire threaded through the fibrous glass insulation and fastened to one inch diameter stainless steel discs which act as buttons. It is similarly held in place by 18 gauge stainless steel wire.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[1] for a list of the pipe break locations for high energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Northern States Power Company.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures F-1 and F-2 are simplified sketches of Prairie Island reactor containment. The reactor vessel, steam generators, pressurizer and associated piping are all located inside the shield wall. The emergency sump, labeled Sump B, is located outside the shield wall on the basement floor at El. 697'-6", and the location is shown in Figure F-2. Figure F-3 and F-4 show the details of the emergency intake sump. The sump is an L shaped cavity in the floor with two pipe intakes for the emergency core cooling system. The sump is covered by a prism shaped screen constructed of 3/4" by 3-11/16" grating. The triangular ends of the screen are 2'-9" high and 2'-11-1/2" wide and the prism length being 8'-9-1/2".

Insulation debris generated either inside or outside the shield wall will principly be reflective metallic with some fibrous material from the main steam and feedwater pipe hangers and restraints. Outside the shield wall, the floors should prevent insulation from reaching the sump, however, a small amount will be transported down stairwells. Inside the shield wall, platforms will catch some of the insulation, however, a large quantity can be transported to the basement floor. The reflective metallic will sink while the fibrous glass insulation will initially float and could be transported to the sump and sink.

H. REFERENCE

1. Prairie Island Units 1 and 2, Final Safety Analysis Report, Northern States Power Company, Minneapolis, MN.

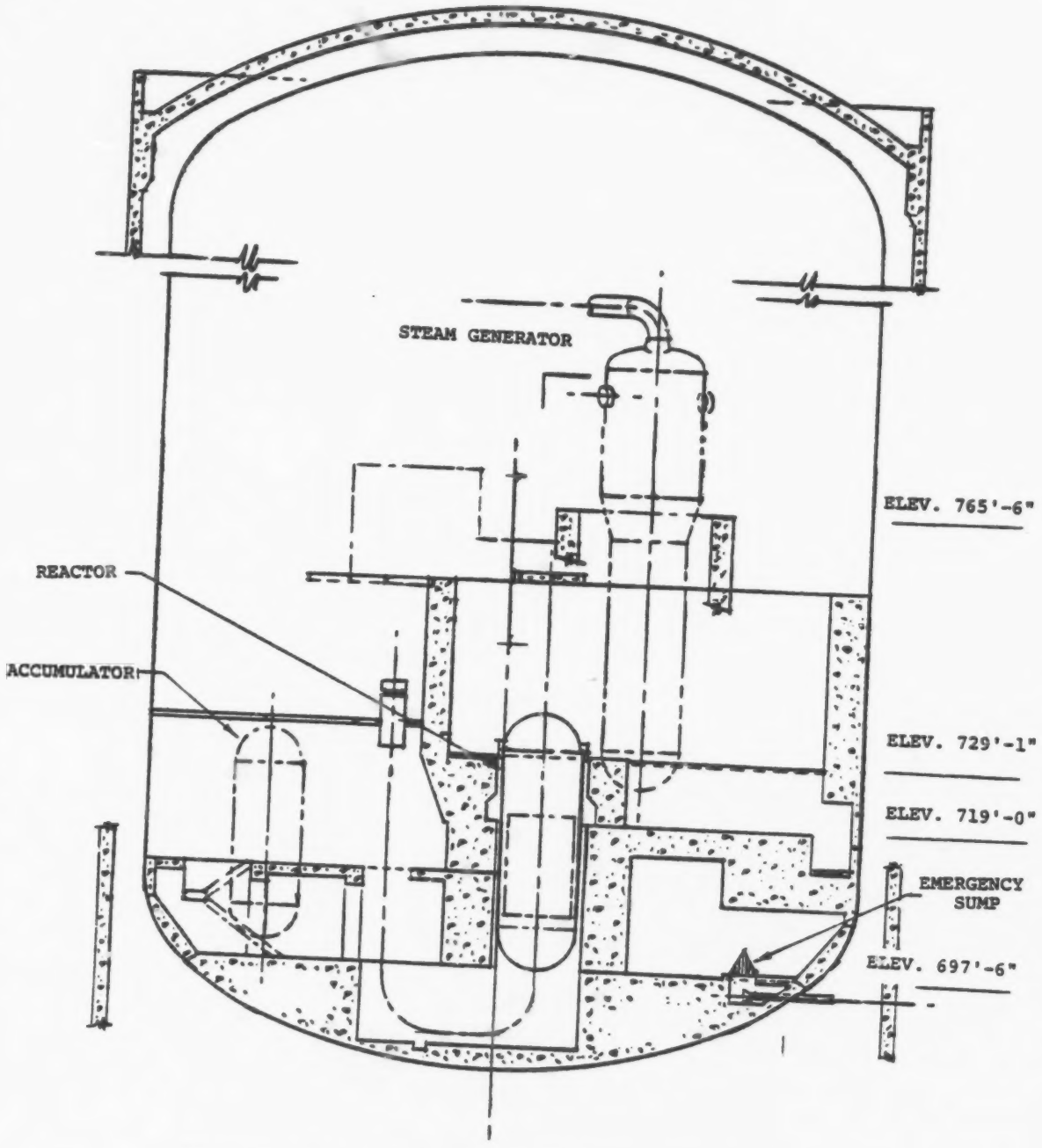

Figure F-1. Reactor Building Elevation, Prairie Island Units 1 and 2

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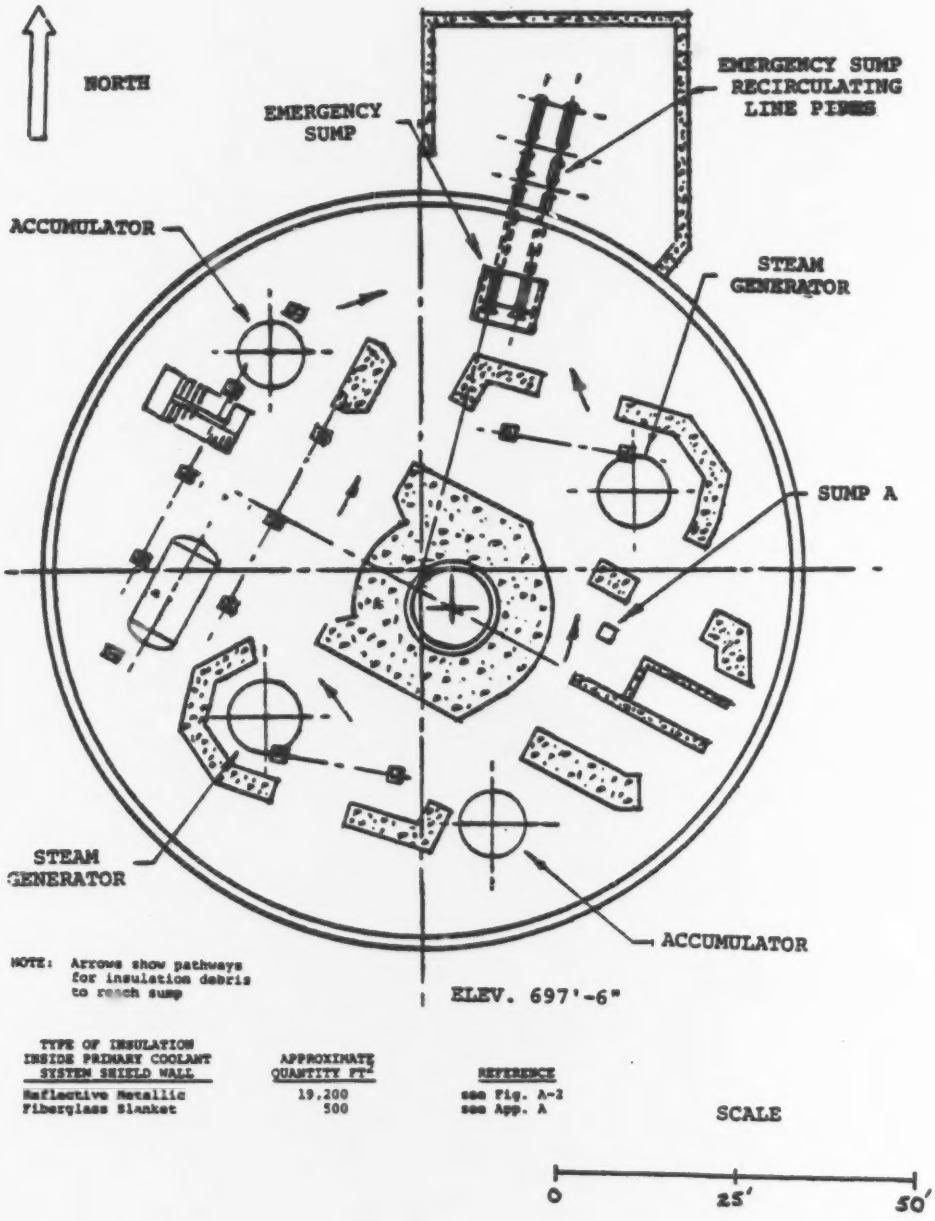

Figure F-2. Reactor Building Plan,
Prairie Island Units 1 and 2

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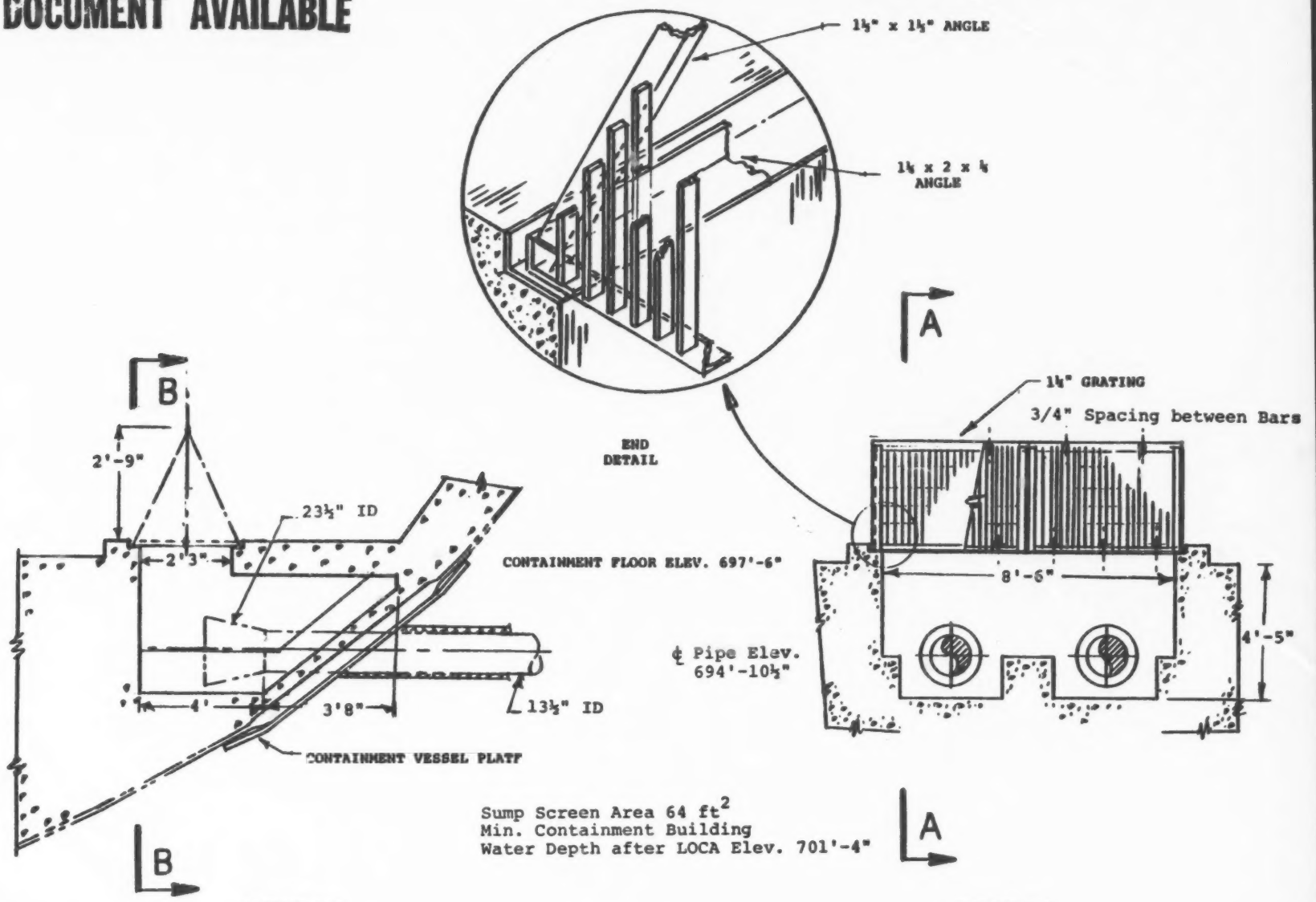

Figure F-3. Containment Sump, Prarie Island Units 1 and 2

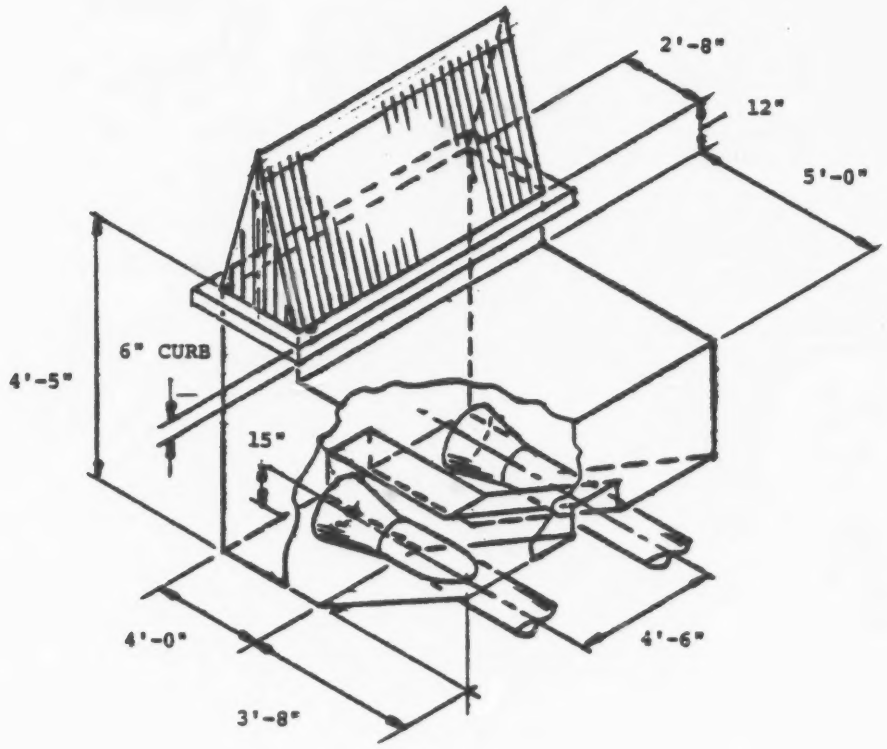

Figure F-4. Containment Sump Isometric, Prairie Island Units 1 and 2

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APPENDIX G
KEWAUNEE UNIT 1

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of the thermal insulation inside the primary containment of the 535 MWe, Westinghouse, PWR Kewaunee Unit No. 1 which began commercial operation in 1974.

The information gathered includes the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculation sump

3. Details of the insulation that could be dislodged and become a source of the debris as a result of a major break.

Stainless steel reflective metallic insulation manufactured by Mirror is used for the pressurizer, reactor coolant pumps, reactor coolant piping, letdown line, safety injection piping, pressurizer surge line, residual heat removal, accumulator and a small proportion of the steam generators. Approximately 85 percent of the steam generators, main steam and feedwater piping are covered with Thermobestos block manufactured by Johns-Manville.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, piping, flow diagrams, emergency sump details and insulation details obtained from Wisconsin Public Service Corporation.

1. Documentation

   a. Letter from Wisconsin Public Service Corporation to NRC dated January 16, 1981 on insulation and the emergency sumps.

   b. Letter from Wisconsin Public Service Corporation to NRC dated August 31, 1981 on the study regarding blockage of containment sumps by insulation.

2. Drawing

   a. General Arrangement - Containment and Reactor Building

      A204-U Basement Floor
      Sh. 2 of 11

A210-K Sh. 8 of 11	Cross Section
S-224F	Elevation Steel Platforms and Ladders Inside Annulus
S-224-1A	Miscellaneous Platforms and Details
S-225F	Steel Platform Framing Plans Inside Annulus
S-253-V	Steel Miscellaneous Platforms
S-254J	Platforms and Ladders Serving Steam Generator Manways
S-254-1G	Miscellaneous Platforms
S-254-3C	Miscellaneous Platforms Steam Generator Weld Inspection Platforms
S-254-4A	Miscellaneous Platforms Serving Upper Part of Steam Pipe
S-254-5B	Miscellaneous Platforms Serving Accumulator & R.T.D. Valves

b. Emergency Sump Design Details

S-237P	Reactor Building Concrete Sections & Details

c. Flow Diagrams for Systems Inside Containment

X-K100-10-S	Reactor, Coolant System
X-K100-18-Q Sh. 1 of 3	Auxiliary Coolant System
X-K100-28P	Safety Injection System
X-K100-36-Q Sh. 2 of 4	Chemical & Volume Control System
M203-DD	Main, Auxiliary Steam Dump
M205-Y	Feedwater System

d. Piping Layout Drawing for System Inside Containment

M324-AD Sh. 1 of 2	Residual Heat Removal
M359-Q Sh. 1 of 4	Chem. & Vol. Control, Auxiliary Coolant & Safety Injection
M360-Q Sh. 2 of 4	Chem. & Vol. Control, Auxiliary Coolant & Safety Injection
M361-U Sh. 3 of 4	Chem. & Vol. Control, Auxiliary Coolant & Safety Injection
M362-S Sh. 4 of 4	Chem. & Vol. Control, Auxiliary Coolant & Safety Injection
M363-Y Sh. 1 of 5	Chem. & Vol. Control, Sample, Reactor Coolant, Waste Disposal
M364-Y1 Sh. 2 of 5	Chem. & Vol. Control, Sample, Reactor Coolant, Waste Disposal
M365-Y Sh. 3 of 5	Chem. & Vol. Control, Sample, Reactor Coolant, Waste Disposal

e. Reactor Building Equipment and Equipment Insulation Drawings

X-K310-2	Mirror Insulation Arrangement for 1000 Cu. Ft. Pressurizer
X-K310-7	Low Head Safety Injection @ El. 517'-10-3/4"
X-310-8	Coolant Piping Insulation
X-K310-11	Intermediate Coolant Leg Loop B
X-K310-13	Steam Generator 1-A Bottom Head Shell Insulation
X-K310-19	Coolant Pump Insulation Arrangement
X-K310-23	Insulation Support Frame Details
X-K310-27	Accumulator Injection Loop A & Loop B
X-K310-30	8" Residual Heat Removal Act
X-K310-32	Surge Line Insulation
X-K310-34	Encapsulation - Main Steam Piping

X-K310-36	Encapsulation - Feedwater Piping
X-K310-45	2" Auxiliary Spray Line From 3" Pressurizer Spray Line
X-K310-48	Safety Injection Loops A & B
X-K310-49	2 Charging Line to Regenerative Heat Exchanger

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the systems inside the reactor containment containing insulation. The list includes the system, nominal pipe sizes inside containment, and the type of insulation used for each system.

System	Nominal Pipe Size (inches)	Type of Insulation
Safety Injection	2, 3, 6	Reflective Metallic
Reactor Coolant System	27-1/2, 29, 31	Reflective Metallic
Pressurizer Surge Line	10	Reflective Metallic
Pressurizer Spray Line	3	Reflective Metallic
Reactor Drain Line	1, 2	Reflective Metallic
Shutdown Cooling System	6, 8, 10	Reflective Metallic
Feedwater	16	Thermobestos
Emergency Feedwater	4	Thermobestos
Pressurizer Safety Relief Valve Lines	6, 6, 10	Reflective Metallic
Main Steam	30	Thermobestos
Equipment Inside Primary Containment		
Steam Generator		85% - Thermobestos 15% - Reflective Metallic
Reactor Coolant Pumps		Reflective Metallic
Reactor Vessel		Reflective Metallic
Pressurizer		Reflective Metallic

D. TYPICAL INSULATION DETAILS

The reflective metallic insulation used for equipment and piping inside containment is manufactured by Mirror Insulation, a unit of Diamond Power Specialty Company. The insulating material used for the reflective insulation is all-metal AISI type 304 stainless steel. The reflective metallic is fastened by one of the following methods: buckles and screws, pop rivets, buckles and keeper, stainless steel band and buckles, stainless steel bands or buckles.

Thermobestos is manufactured by Johns-Manville. The Thermobestos is asbestos fibers mixed with an inorganic hydrous calcium silicate binder encapsulated using AISI type 304 stainless steel. It is fastened by stainless steel bands.

E. PIPE BREAK LOCATIONS

Refer to the FSAR[1] for a list of the pipe break locations for high energy piping inside the primary containment.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTION

None were submitted.

G. PRELIMINARY INSULATION DEBRIS HAZARDS ANALYSIS

Figures G-1 and G-2 are simplified sketches of the Kewaunee Unit No. 1 reactor containment building. The reactor vessel, steam generators, reactor coolant pumps, pressurizer and associated piping are located inside the shield wall. The location of the emergency sump on the basement floor at El. 592'-0" is shown in Figure G-2 and is outside the shield wall. Figures G-3 and G-4 show the details of the emergency intake sump. The sump is an L shaped cavity in the floor with two pipes intakes for the emergency core cooling system. Covering the sump is a flat rectangular checker plate with two cone shaped screens over each intake pipe. The conical shaped screens are basket stainless steel type 304 water strainer catalog Johnson Screens by U.O.P. Saint Paul, Minnesota. Opening slots within the screen are 1/8" wide with 60% open area.

Outside the shield wall, the potential for large amounts of the insulation debris reaching the sump is small. A floor at El. 606'-0" will capture most of the insulation before it reaches the basement floor. However, a small amount of insulation will migrate to the basement floor through stairwells and other openings in the floor. The potential for large amounts of insulation debris reaching the sump from inside the shield wall exists. Two partial floors exist within the shield wall at El. 605'-4" and El. 609'-1". Although these floors will capture much of the insulation, some could pass through the gap between the two floors to reach the sump. Any insulation below the floor at El. 606'-0" and El. 605'-4" will reach the basement floor. In the region surrounding the sump, there exists several pipes above the sump. The largest of these pipes is a 10 inch residual heat removal pipe. A pipe break could dislodge the insulation from these pipes and the insulation could land on the sump.

The insulation debris generated from a pipe break will be a mixture of reflective metallic and the Thermobestos. The reflective metallic will sink and the Thermobestos, because of its density (11 lb/ft^3), will float and then sink as it absorbs water.

H. REFERENCE

1. Kewaunee, Final Safety Analysis Report, Wisconsin Public Service Corporation, Green Bay, WI.

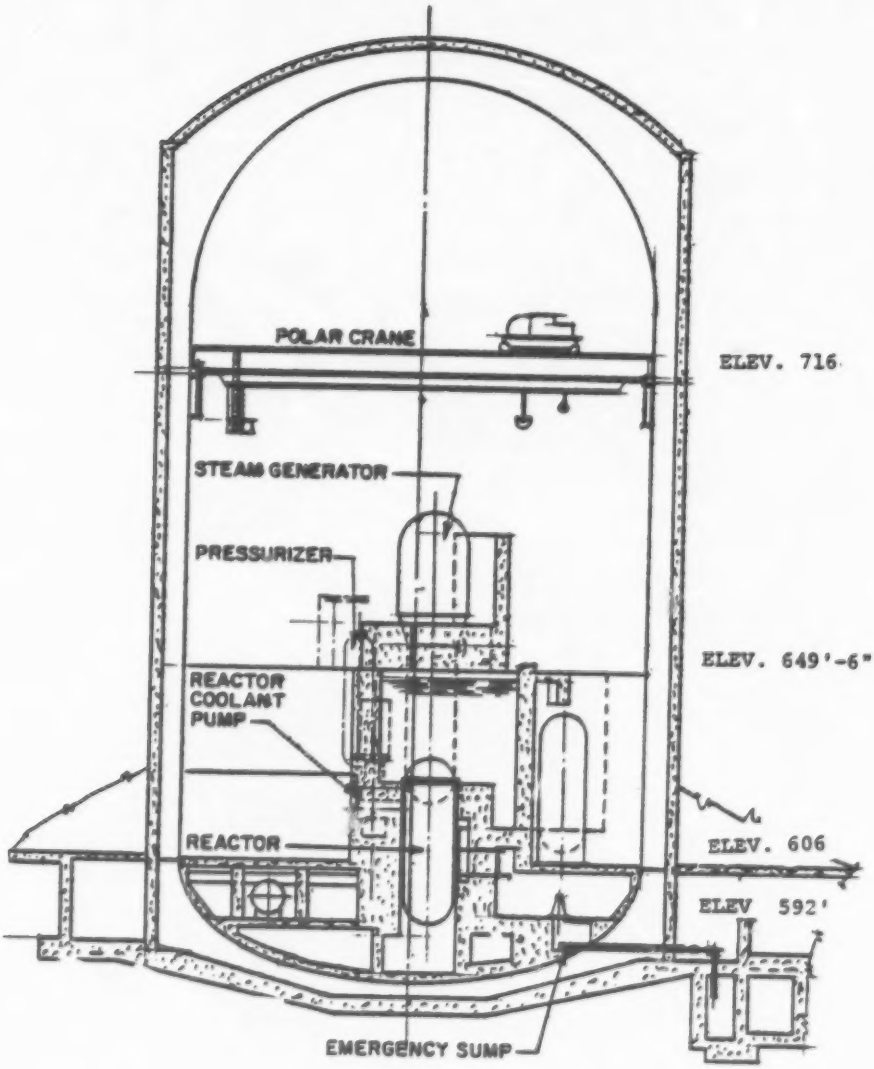

Figure G-1. Reactor Building Elevation, Kewaunee

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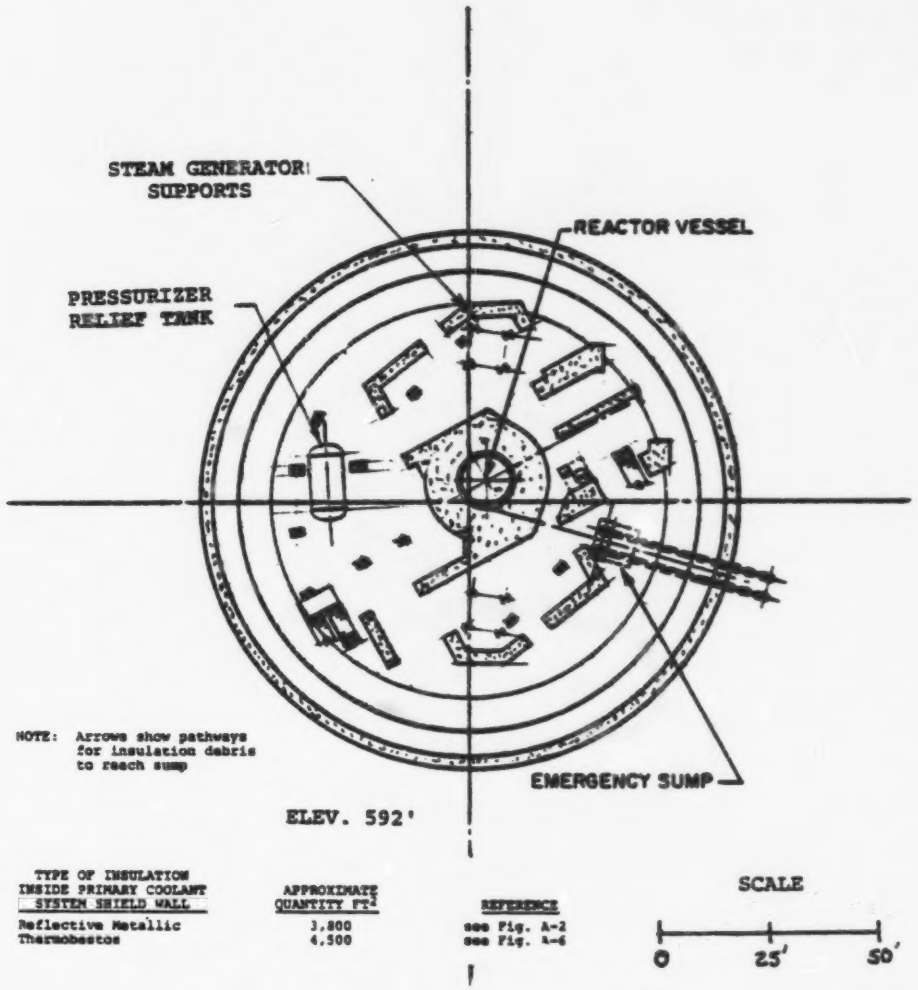

Figure G-2. Reactor Building Plan, Kewaunee

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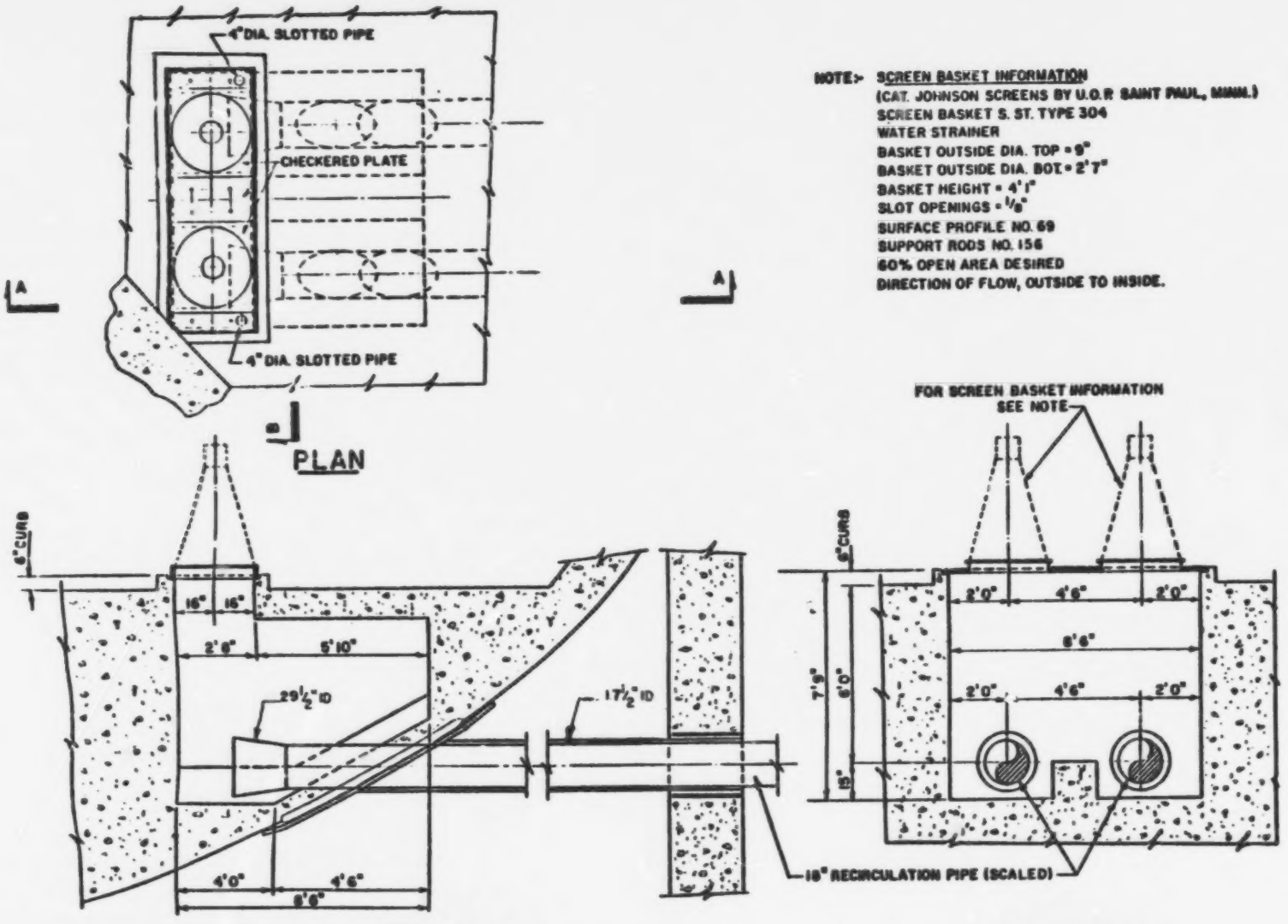

SECTION A-A

SECTION B-B

Sump Screen Area 94 ft^2
Min. Containment Building
Water Depth after LOCA Elev. 595'-9"

Figure G-3. Containment Sump, Kewaunee

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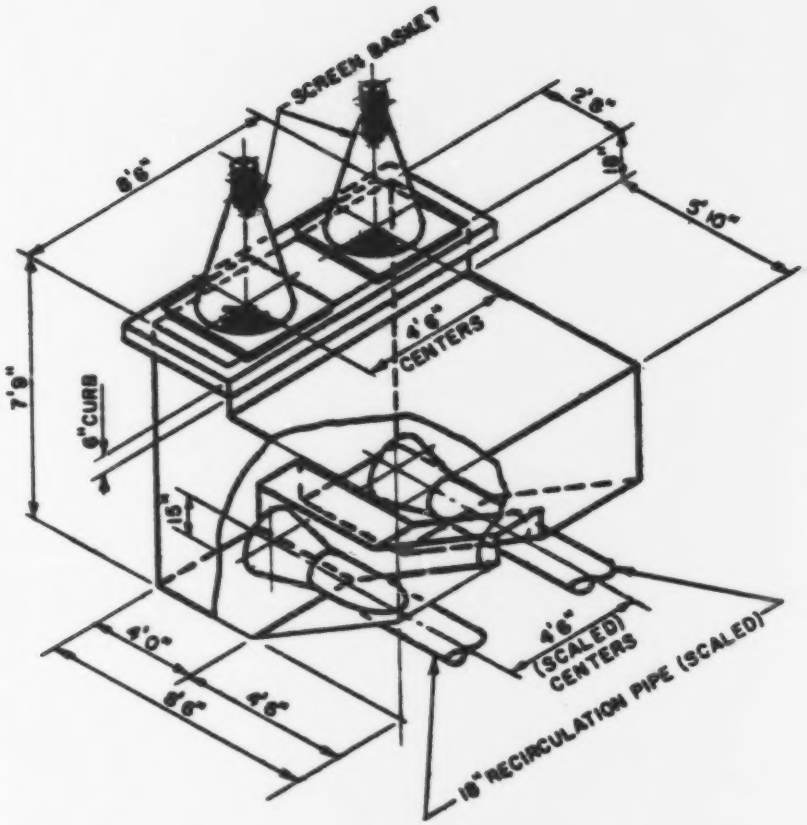

Figure G-4. Containment Sump Isometric, Kewaunee

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APPENDIX H
HADDAM NECK UNIT 1

PRELIMINARY ASSESSMENT OF
INSULATION DEBRIS GENERATED DURING A
PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 575 MWe Westinghouse, PWR, Haddam Neck Station which started commercial operation in 1968.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the sump for emergency core cooling, and the communicating paths by which debris generated by a major pipe break could reach the emergency recirculating sump

3. Details of the insulation that could be dislodged and become a source of debris as the result of a major break.

Thermobestos insulation is used for the reactor pressure vessel and hot pipes. Fiberglass insulation is used at valves and welds for the removable sections. Foam insulation is used for the cold water pipes.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, piping, flow diagrams, emergency sump details and insulation details obtained from Connecticut Yankee Atomic Power Company and Northeast Utilities.

1. Documentation

   a. Letter from Connecticut Yankee Atomic Power Company to Nuclear Regulatory Commission dated February 27, 1981 on the insulation within the plant.

2. Drawings

   a. General Arrangement - Containment and Reactor Building

10899-FM-2A	Containment EL 1'6" and EL (-) 16'0"
10899-FM-2B	Containment EL 16'0"
10899-FM-2C	Containment EL 22'0"
10899-FM-2D	Containment EL 48'6"
10899-FM-2E	Containment Sections AA and BB
10899-FM-2F	Containment Sections CC and DD

   b. Emergency Sump Design Details taken from General Arrangement Drawing

c. Flow Diagrams for Systems Inside Containment

10899-FM-12A	Misc. Lines
540F415	Reactor Coolant System
540F416	Auxiliary Coolant System
540F420	Safety Injection System
10899-RM-6A	Condensate Feedwater and Heater Drain Lines
16103-26013 Sht. 2	Condensate Feedwater and Drain Lines
10899-RM-7A	Circ. and Service Water Lines
10899-RM-39A	Operating Valve Numbers Main, Aux. St., Extraction St. and Air Removal Lines

d. Piping Layout Drawings for Systems Inside Containment

10899-FP-3C	Reactor Containment Piping
10899-FP-3D	Reactor Containment Piping
10899-FP-3E	Reactor Containment Piping
10899-FP-3F	Reactor Containment Piping
10899-FP-3G	Reactor Containment Piping
10899-FP-3H	Reactor Containment Piping
10899-FP-3J	Reactor Containment Piping
10899-FP-3K	Reactor Containment Piping
10899-FP-3L	Reactor Containment Piping
10899-FP-3M	Reactor Containment Piping
10899-FP-3N	Reactor Containment Piping
10899-FP-3Q	Reactor Containment Piping
10899-FP-3R	Reactor Containment Piping
10899-FP-3S	Reactor Containment Piping
10899-FP-3T	Reactor Containment Piping
10899-FP-3W	Reactor Containment Piping

e. Reactor Building Equipment and Equipment Insulation Drawing

None were provided

C. LISTING OF PIPING SYSTEMS INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the equipment and systems inside primary containment containing insulation. The list includes the equipment, the system, nominal pipe sizes inside containment and the type of insulation used for each system.

System	Nominal Pipe Sizes (inches)	Type of Insulation
Safety Injection	6, 8	Thermobestos
Pressurizer Surge Line	10	Thermobestos
Reactor Coolant System	27-1/2, 29	Thermobestos
Reactor Drain Lines	1, 1-1/2, 2	Thermobestos
Shutdown Cooling	4, 8	Thermobestos
Feedwater	12	Thermobestos
Emergency Feedwater	6	Thermobestos
Main Steam	24	Thermobestos
Service Water	1, 2, 3, 6	Foam Insulation
Charging Line	10	Calcium Silicate
Pressurizer Reflief Line	3, 10	Calcium Silicate
Equipment Inside Primary Containment		
Reactor Vessel		Thermobestos
Reactor Coolant Pump		Thermobestos
Pressurizer		Thermobestos
Steam Generator		Thermobestos
Containment Wall		Polyurethane

All valves, welds, etc., requiring removable insulation are covered with fiberglass.

D. TYPICAL INSULATION DETAILS

The Thermobestos, manufactured by Johns-Manville, is asbestos fiber mixed with an inorganic hydrous calcium silicate binder. It is fastened with stainless steel wire and either asbestos cement and aluminum impregnated asbestos cloth or asbestos paper and aluminum impregnated asbestos cloth. The fiberglass, manufactured by Clarmont, is wired in place with stainless steel wire and enclosed in aluminized glassback cloth. The foam insulation is Acrotube, molded from plastic manufactured by Johns-Manville. It is held in place with Johns-Manville 57 Adhesive and tape. The polyurethane is also manufactured by Johns-Manville. It is held in place with adhesive and covered with aluminum impregnated asbestos cloth. The reflective metallic is manufactured by Transco and is held in place with stainless steel banding. The calcium silicate manufactured by Johns-Manville is Thermal 12. The blocks are retained by 10 gauge aluminum jacket and banded in place.

E. PIPE BREAK LOCATIONS

Design Basis Accident pipe breaks are defined as:

1. Steam line rupture at the Steam Generator outlet nozzle

2. Loss-of-coolant accident - double-ended guillotine break in the cold leg at the reactor coolant pump discharge.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were submitted by Connecticut Yankee Atomic Power Company.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures H-1 and H-2 are simplified sketches of the Haddam Neck reactor containment building. The reactor vessel, steam generators, reactor coolant pumps, pressurizer, and associated piping are located inside the shield wall. Figure H-2 shows the location of the emergency sump on the floor of the containment building at an elevation of 1'-6". Figure H-3 shows the details of the emergency sump. The sump is a part of the reactor building sump and has a screen and weir partitioning it from the remainder of the normal sump. Drainage trenches around the outside of the reactor vessel containment wall and around the outside of the shield wall drain into the normal sump and thereby connect to the emergency sump. The drainage trenches are shown in Figure H-2 and are covered by grating. The sump is located adjoining the inside of the shield wall and adjoining a wall which shields the sump from reactor coolant loop number 1. The sump is also shielded from reactor coolant loop number 4 by the fuel transfer canal. A floor is located over the sump at 22'0".

For a pipe break inside the shield wall, the possibility exists for a large amount of insulation to migrate towards the sump and sink. Since most of the insulation will initially float, it could be transported toward the sump once recirculation has begun. For a pipe break outside the shield wall, the potential for a large amount of insulation to migrate towards the sump is very small. A concrete and grate floor exist at El. 22' and would catch most of the insulation. However, a small amount of insulation could migrate down the stairwells and other openings. For a pipe break below the floor at 22', the insulation could migrate to the sump through any hole in the shield wall.

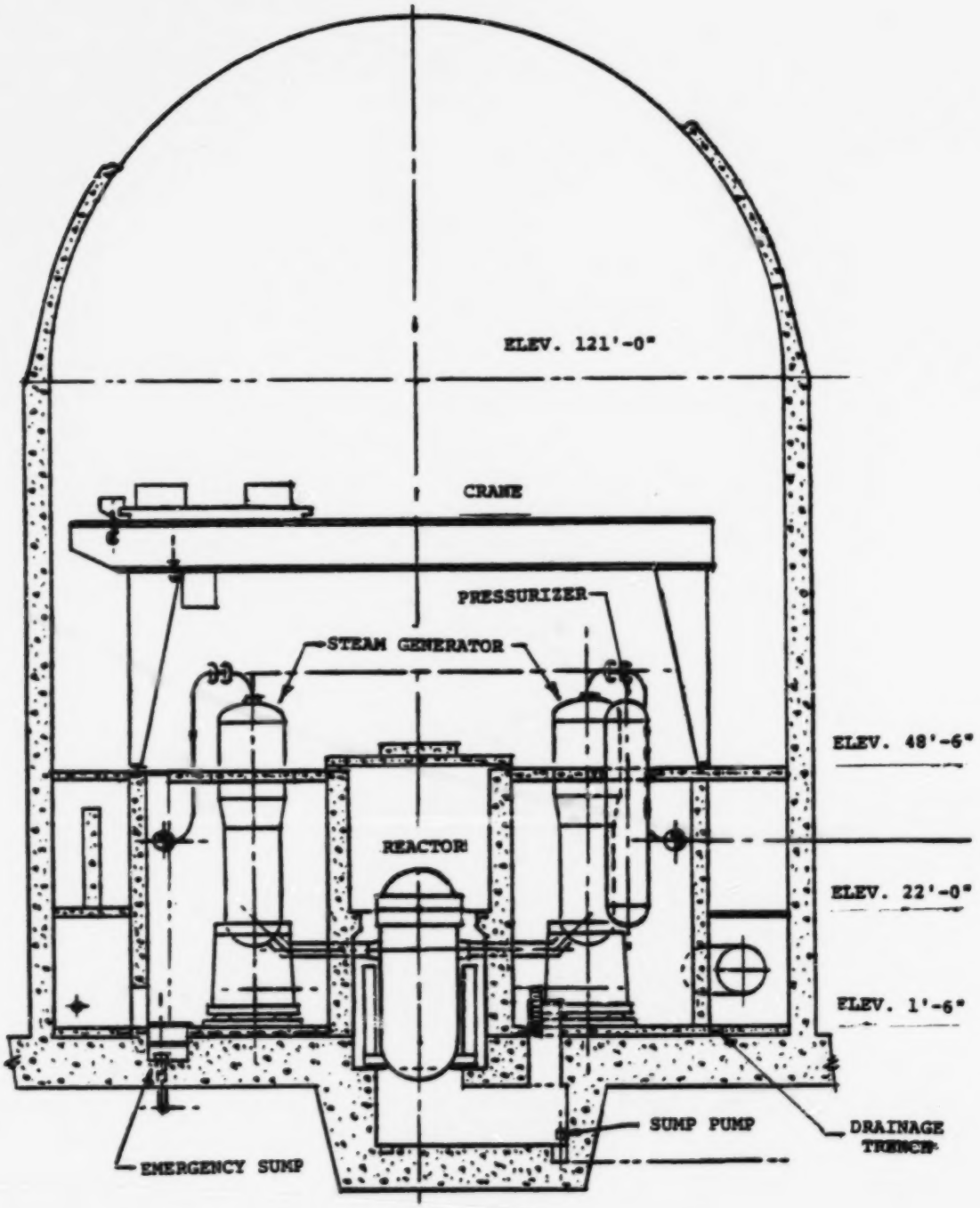

Figure H-1 Reactor Building Elevation, Haddam Neck

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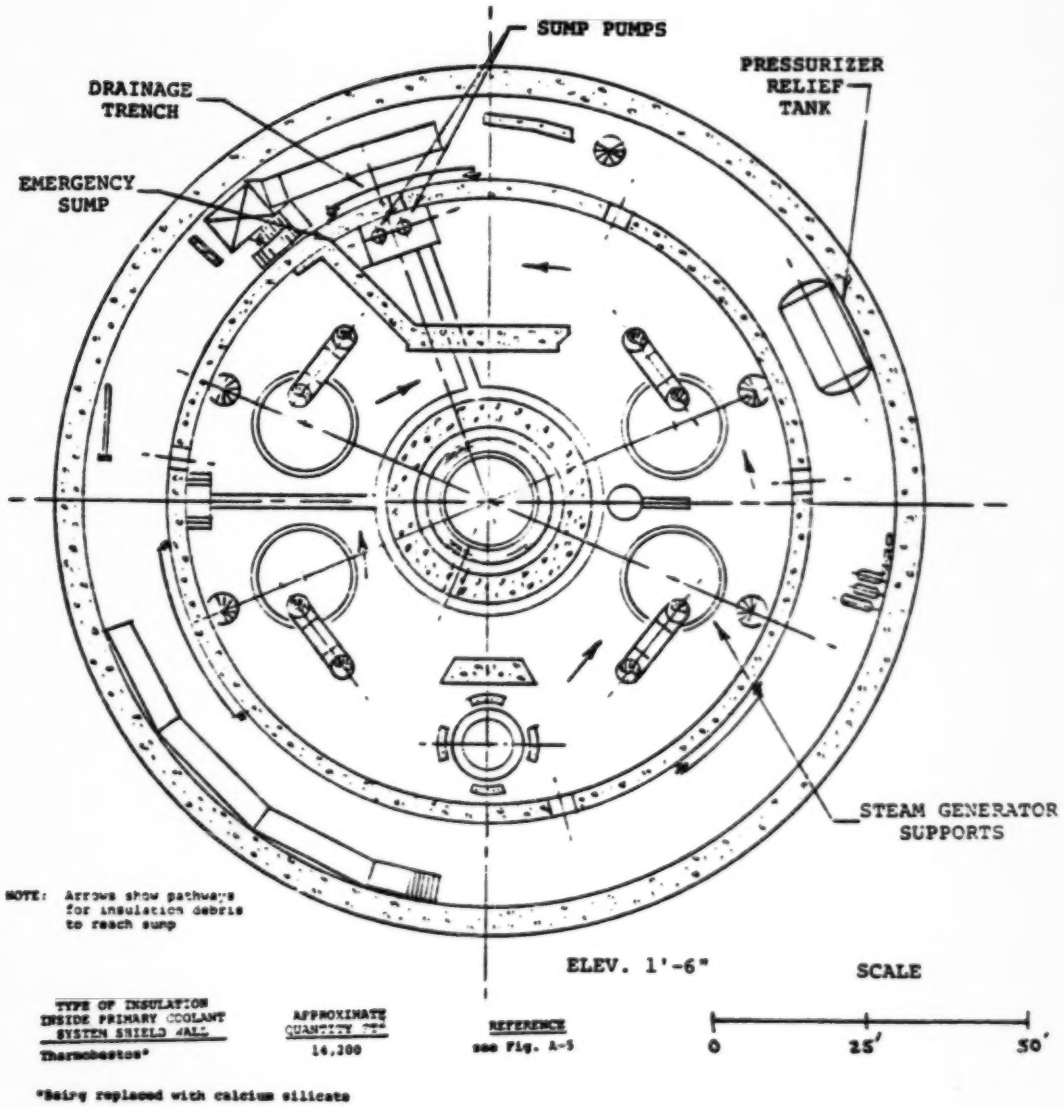

Figure H-2. Reactor Building Plan, Haddam Neck

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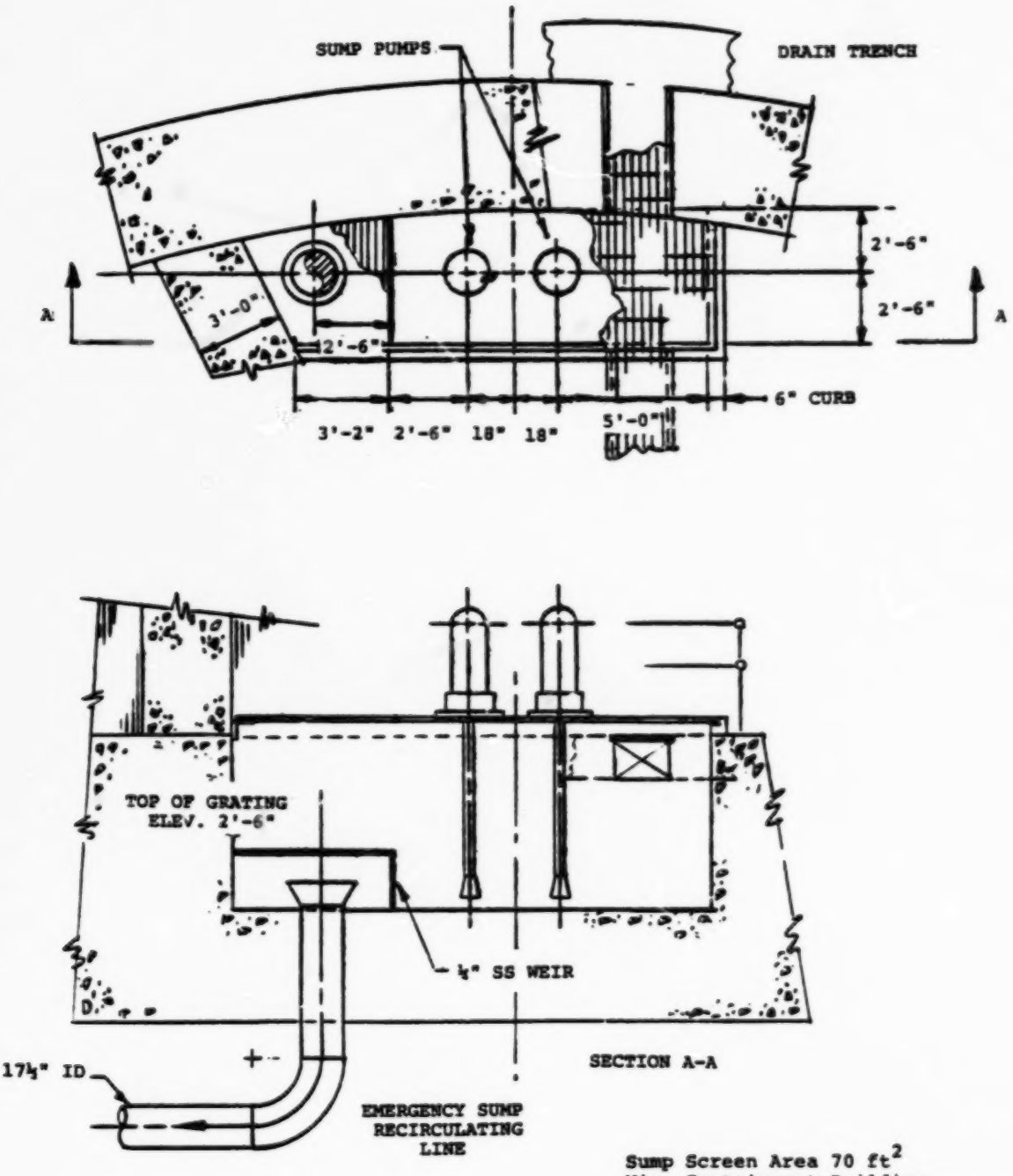

Figure H-3. Containment Sump,
Haddam Neck

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APPENDIX I
H. B. ROBINSON

PRELIMINARY ASSESSMENT OF INSULATION DEBRIS GENERATED DURING A PIPE BREAK EVENT

A. INTRODUCTION

This report documents the information gathered by Burns and Roe's survey of thermal insulation inside the primary containment of the 665 MWe Westinghouse, PWR, H.B. Robinson Nuclear Station which started operation in 1971.

The information gathered depicts the following:

1. The arrangement of all piping within the primary containment including high energy fluid piping

2. The location and configuration of the emergency intake sump for emergency core cooling, the communicating paths by which debris generated by a major pipe break could reach the emergency recirculation sump

3. Details of the insulation that could be dislodged and become a source of debris as a result of a major break.

Unibestos block and pipe covering was initially used throughout the plant for all equipment and systems. Presently, new or replacement insulation is Thermon-12 manufactured by Johns-Manville Company. Approximately 15 percent of the originally installed insulation has been replaced by Thermon-12.

B. LISTING OF INPUT DRAWINGS AND OTHER DOCUMENTS

This section provides a listing of drawings and documents showing details of containment and reactor building, piping, flow diagrams, emergency sump details and insulation details obtained from Carolina Power & Light Company or the NRC.

1. Documentation

   a. Letter from Carolina Power & Light Company to NRC dated February 24, 1981 on the containment sumps and insulation.

2. Drawings

   List of Safety Analysis Report Figures provided by NRC

Figure 1.2-2	General Arrangement Reactor Building Plans Sheet 1
Figure 1.2-3	General Arrangement Reactor Building Plans Sheet 2
Figure 1.2-4	General Arrangement Reactor Building Sections

Figure 5.1.2-37	Reactor Building Base Slab Sections Mas.
Figure 6.2-2	Safety Injection System - Plan Sheet 1
Figure 6.2-3	Safety Injection System - Plan Sheet 2
Figure 6.2-4	Safety Injection Systems Sections
Figure 6.2-5	Residual Heat Removal Piping

C. LISTING OF PIPING INSIDE CONTAINMENT CONTAINING INSULATION

This section provides a list of the equipment and systems inside primary containment containing insulation. This list includes the equipment, the system, nominal pipe sizes inside containment and the type of insulation used for each system.

System	Nominal Pipe Size (inches)	Type of Insulation
Chemical and Valve Control	Not Provided	Unibestos*
Reactor Coolant	Not Provided	Unibestos*
Safety Injection	10	Unibestos*
Component Cooling Water	Not Provided	Unibestos*
Service Water	Not Provided	Unibestos*
Steam Generator Blowdown	Not Provided	Unibestos*
Main Steam	Not Provided	Unibestos*
Residual Heat Removal	Not Provided	Unibestos*
Sampling System	Not Provided	Unibestos*

Equipment Inside Primary Containment	
Steam Generator	Unibestos*
Pressurizer	Unibestos*
Regenerative Heat Exchanger	Unibestos*
Reactor Coolant Pump	Unibestos*
Excess Letdown Heat Exchanger	Unibestos*

* 15 percent of the Unibestos insulation has been replaced with Thermon-12, a molded hydrous calium silicate.

D. TYPICAL INSULATION DETAILS

The Unibestos insulation used inside containment is of molded construction. For all piping 12 inch nominal diameter and smaller, 36 inch sections having not more than two longitudinal joints were used. For all piping over 12 inch nominal diameter and all bends 2 piece block molded to fit the circumference of the pipe were used. All segmental blocks were butted together and wired in place with No. 16 gage annealed iron wire. The ends of all wire loops were firmly twisted together with pliers, bent over and carefully pressed into the surface of the insulation. All irregularities in the insulation were smoothed out with an application of hard finish cement, composed on the same material as the molded insulation blocks, sufficient only to provide a uniform, even surface but not intended as a hard cement finish coat. Finally, a layer of white duck was applied to the insulation.

E. PIPE BREAK LOCATIONS

None were provided.

F. FSAR REFERENCES ON PERTINENT INSULATION QUESTIONS

None were referenced.

G. PRELIMINARY INSULATION DEBRIS HAZARD ANALYSIS

Figures I-1 and I-2 are simplified sketches of the H. B. Robinson Unit 2 reactor containment. The reactor vessel, steam generators, pressurizer and associated piping are located inside the shield wall. The accumulator and its associated piping are located outside the shield wall. The emergency sump is located outside the shield wall on the basement floor at El. 228'-0". Figure I-2 shows the sump location and screens on the outside of the shield wall. The details of the emergency intake sump are shown in Figure I-3. The sump, a pit in the floor 1 ft. deep and 12 ft. long and 3 ft. wide, located next to the shield water. Surrounding the sump are two baffles.

A screen slopes from the outer edge of the sump making contact with the shield wall. Inside the shield wall, screens cover passages 2' x 2' leading to the outer annulus formed by the shield wall and containment wall. These inner screens contact the floor, inside the shield wall and slopes toward the shield wall.

For pipe breaks inside the shield wall, the potential for a larger amount of insulation debris reaching the emergency sump does not exist. Any insulation reaching the floor at El. 228'-0" inside the shield wall, must pass through the screens covering the drain passage. Therefore, to reach the outer annulus, insulation debris too large to pass through the screens would have to go through uncovered openings in the shield wall at elevations above the containment building water level after a LOCA.

For a pipe break outside the shield wall, the potential for large amount of insulation debris reaching the emergency sump is very small for any breaks above El. 251.50. A floor at El. 251.50 will catch most of the insulation. A small amount of insulation will pass down stairwells and other openings. Below the 251.50 elevation, the insulation can float to the emergency sump. The baffles and sump screen will catch this insulation.

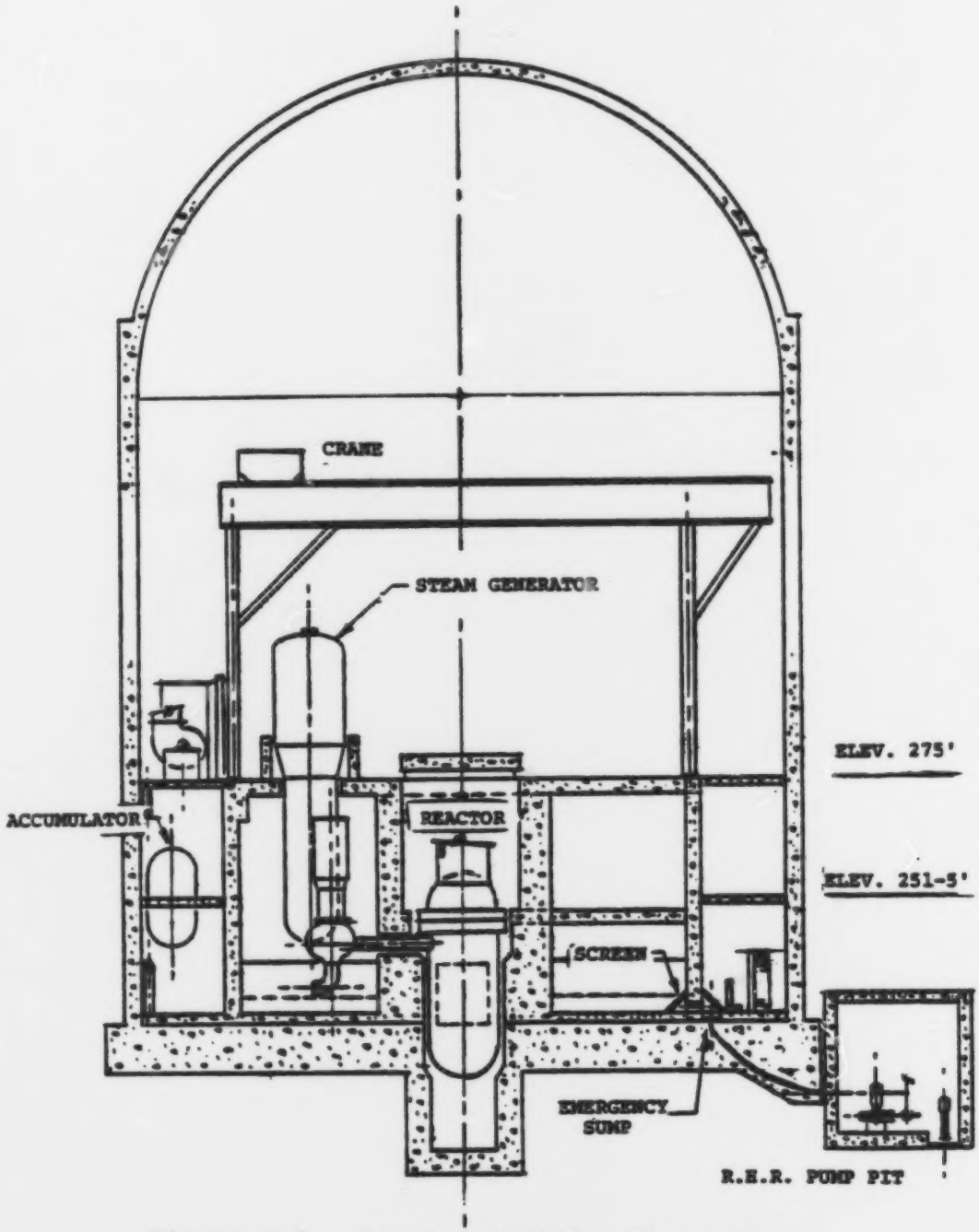

Figure I-1. Reactor Building Elevation, H. B. Robinson

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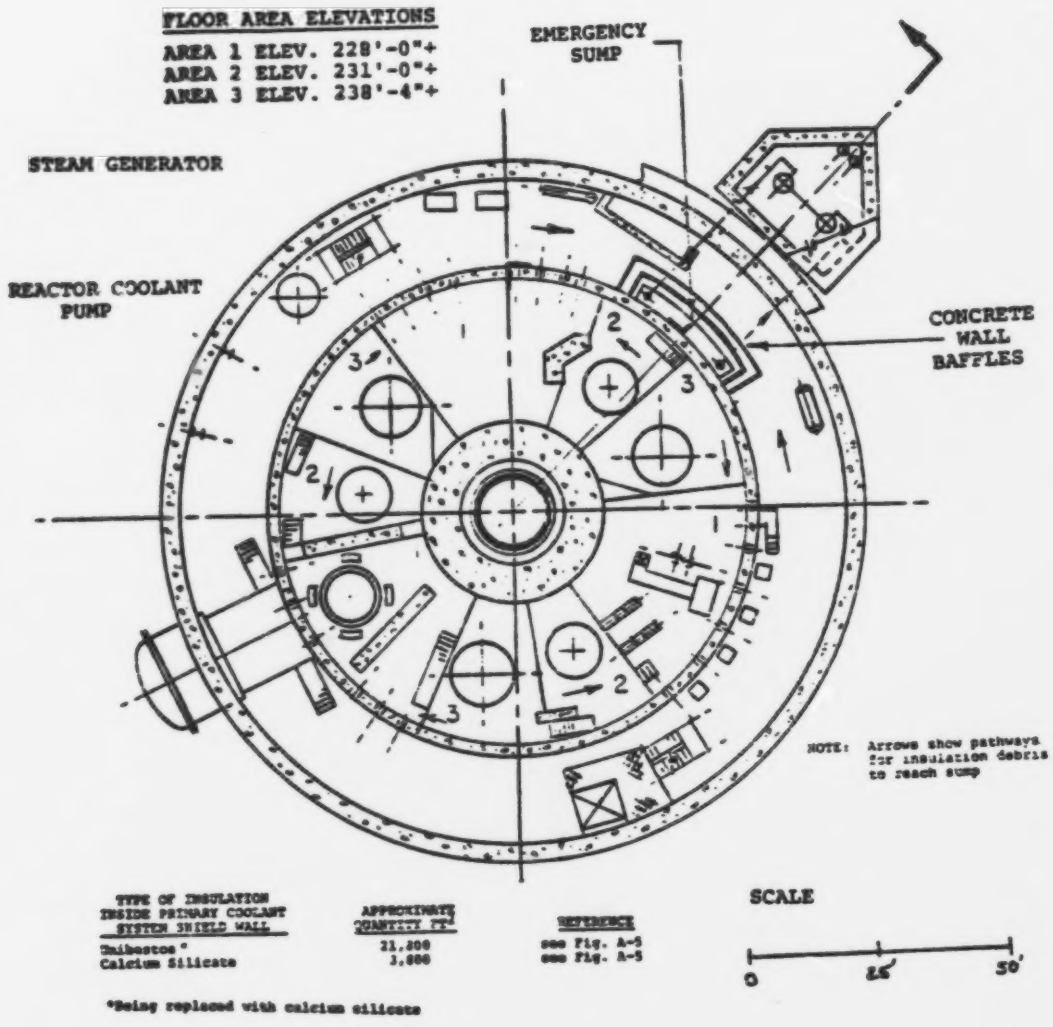

Figure I-2. Reactor Building Plan,
H. B. Robinson

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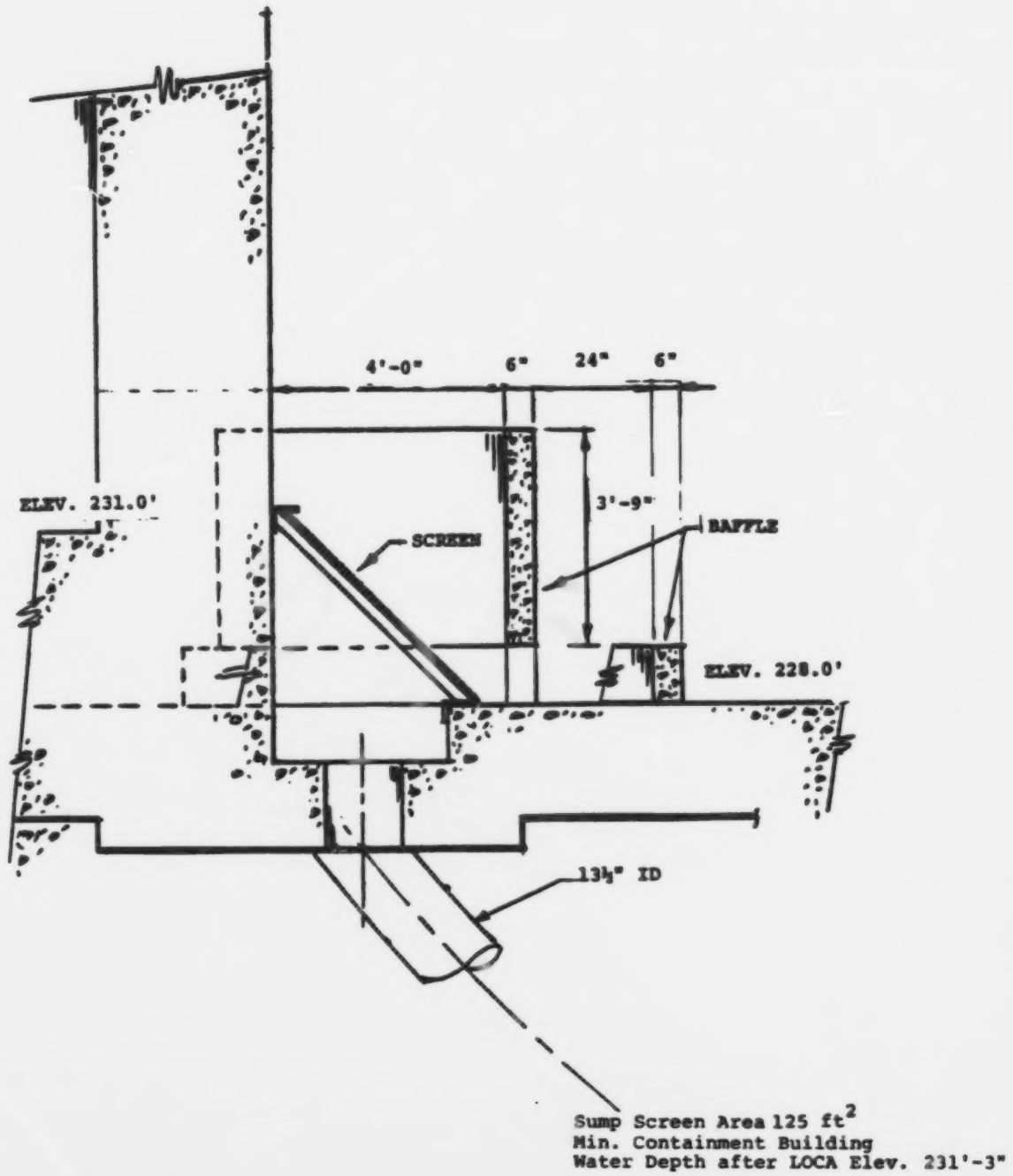

Figure I-3. Containment Sump,
H. B. Robinson

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In support of Unresolved Safety Issue, USI A-43, "Containment Emergency Sump Performance," 8 additional nuclear power plants (representative of different U.S. reactors' manufacturers and architect-engineers) were surveyed to identify and document the types and amounts of insulation used, location within containment, components insulated, material characteristics, and methods of installation and attachment. These plants were selected to obtain survey information on "older" plants and supplements survey information previously reported in NUREG/CR-2403. In addition, a preliminary assessment was made of the potential for migration of the insulation debris which might be generated as a result of the postulated loss-of-coolant accident (pipe break).

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